THE
PESTS AND BLIGHTS
OF THE
TEA PLANT

BEING

A REPORT OF INVESTIGATIONS CONDUCTED IN ASSAM AND TO SOME EXTENT ALSO IN KANGRA

BY

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CHAPTER I.

EXTENT OF PERSONAL EXPLORATIONS.

IN response to an application made by the Indian Tea Association, the Government of India authorized me to pay a visit to certain of the Tea Districts in order to institute enquiries mainly into the subject of Tea Blights and the value of **Adhatoda Vasica** as an insecticide against the injury done by the more alarming insect pests. **Official Instructions.** **Adhatoda.** ***Conf. with paras. 20-2, 222, 573, 589, 704, 742, 758 and 795.***

2. The greater importance of Assam as a tea-producing country has necessitated a larger portion of this report being devoted to the particulars learned in that province than has been given to Kangra. It is believed, however, that the opinions advanced are applicable not only to Assam and Kangra, but to some extent at least to the tea districts of India as a whole. The present report is intended purely and simply as a *popular statement,* since it would take many years to do justice to the subject or even to fully work up the mass of material that had been collected during the few months spent in Assam and Kangra. It is issued in the hope that it may prove of some slight practical value, but chiefly from the expectation that I **Nature of Report.** ***Conf. with paras. 54, 55, 92, 314.***

Future Enquiry.

may possibly succeed to awaken interest in certain directions and in subjects of enquiry that need to be very considerably elaborated before anything of a definite character can be established. By having a report that touches on such points, though only in a popular (and one might almost call it a speculative) form, it may be possible to lay down the lines on which a more detailed enquiry should be conducted. But I may say at once that my visit to Assam convinced me most completely that the investigations I had been deputed to undertake in a few months, could only be accomplished by a scientific officer residing in the tea districts for some ten years or so and conducting a series of complicated and delicate investigations in intimate association with the planters. In fact the study is one that might easily be regarded as sufficient to occupy the whole time and attention of several investigators for a life-time. The utmost I can hope, therefore, to accomplish by the present report may be said to be, to establish general principles for future guidance; to direct attention to the subjects that seem of greatest moment; and to construct a basis of mutual action between the practical planter and the scientific investigator, who may ultimately work up the material already collected and that which, it is hoped, may be furnished continuously by the planters as one result of this preliminary statement. With the last-mentioned object in view I shall endeavour to exhibit the gaps that require to be filled up in our Museum sets of specimens and to indicate some of the simpler experiments that have to be performed before we can speak even in general terms of some of the most serious blights.

General Principles.

Collections of Pests.

3. The present report will, as far as possible, be confined to the subject of tea and shall only incidentally deal with the other botanical enquiries conducted by me during my explorations in Assam and Kangra.

Names of Tea Gardens.

4. It is not intended that mention should be made of gardens in which certain blights were found to prevail, but it may be of value to record here the chief centres visited by me and the dates of my movements. The periods of appearance and disappearance of certain blights is of distinct importance. Moreover, my not having seen certain blights in some of the gardens visited, may be accounted for by my having reached these gardens too early or too late in the season, as the case may be.

Extent of Personal Explorations.

I.—Localities visited and Dates of my Tour in Kulu and Kangra.

TOUR in KANGRA.

5. On the 8th October 1894 I visited Bajoara, and crossing the Babbu Pass into Nugger I followed the valley down to Sultanpur, which was reached on the 27th; I then directed my steps from Kulu to Kangra *viâ* the Jatingri Pass and reached Baijnath on the 4th November. Several gardens and tea houses owned and worked by Natives were then inspected; the 6th was spent at Soongal; 7th at Holta; 8th at Palampur; 9th at Gopalpur; and 10th at Dharmgiri. As many gardens as possible were visited around the centres named.

II.—Localities visited and Dates of my Movements in Assam.

TOUR in ASSAM.

6. I left Calcutta on the 12th of March and returned again on the 25th July 1895. Deducting the time occupied by journeying in train and steamer to and from the province, it may be said that my explorations occupied a little over three and a half months. But of that short period fully one month was taken up in botanical investigations which, from the results obtained, may be pronounced as having had but a negative or at most an indirect bearing on the subject of tea blights. The report which I have now the honour to present represents, therefore, the results obtained during little more than two months' explorations in the Assam tea districts.

Sibsagar.

7. *Sibsagar District.*—I reached Sibsagar on the 18th March, and up to the 5th April devoted myself to the study of the gardens and neighbouring jungles in the vicinity of Nazira. The following were the chief gardens visited :—Ligri Pukri, Mazenga Maikipur, Bamon Pukri, Suntok, Cherideo, Dholebagan, Gileki, Atkhel, and Deopani. From Suntok I went for a few days on an excursion up the Dekho river and collected many plants of interest, but failed to trace more than one or two of the tea blights into the jungles. I also inspected some of the seams of coal in the trans-Dekho Naga country. Similarly from Gileki I made a botanical excursion into the jungles on the lower hills that skirt the tea gardens and witnessed the primitive mining operations of the Nagas and others employed on the seams or rather pouches of nummulitic coal of that locality.

I then turned to what may be called the more north-eastern portions of the Sibsagar tea district. On the 6th of April I went to

Extent of Personal Explorations.

TOUR in ASSAM.

Dumar Dallang; 7th, Khumtai; 8th, Moran and Khwang; 9th, Sepon; 10th, Naharani; 11th, Luckwah; 12th, Nahorhabi; and 16th, back to Ligri Pukri.

Jorhat.

8. *Jorhat.*—I next visited the south-western section of the Sibsagar gardens by revisiting on the 18th and 19th Atkhel; Amguri, 20th and 21st; Tiphuk, 22nd; Selang, 23rd; Noakachari, 24th; Jetukia (Melang), 25th; Cinnamara, 26th; Moaband and neighbourhood, 27th-29th.

Golaghat.

9. *Golaghat.*—Nigiriting, 30th April and 1st May; Badalipar, 2nd; and 3rd to 5th other gardens in the Nigiriting neighbourhood. On the 6th May I proceeded to the gardens near the Golaghat Station. Having already amassed a considerable amount of information regarding tea pests and blights, it was felt desirable that I should make a run through the Naga Hills. Besides the subject of tea, my orders were to institute enquiries regarding other matters and to make certain collections of economic products. I had failed to find in the jungles around the tea gardens more than one or two of the tea blights, and the opinion had been forced on me, therefore, that the majority of the more alarming maladies had been induced by cultivation. It was accordingly recognized as very desirable that I should have an opportunity to study indigenous tea in its natural habitat.

Nambar Forest.

10. *Nambar Forest.*—On the 7th to the 10th of May I marched through the Nambar forest to Dimapur. Many botanical and economic collections were made, but again I failed to find any more of the tea blights in these very extensive jungles. Two plants were, however, seen to be punctured in a manner very similar to that effected by the Tea Mosquito. These were **Polygonum sp.** and **Mæsa indica.** Although I spent several hours watching the former, I was unsuccessful in identifying the insect, but the puncturings were seen to be very different in shape to those on the tea plant, and therefore I inferred that they were in all probability not caused by **Helopeltis theivora**—the Mosquito. The latter plant (**Mæsa**), a small bush common all over the plains and lower hills of Assam, up to altitudes of 3,000 feet, had its leaves punctured very much like those of the tea plant. I was aware the insect responsible for this had been identified by Entomologists as allied to the mosquito of the tea, though quite distinct. I soon confirmed that opinion. It is a bright red creature, the wingless larvæ of which might be described as almost

Extent of Personal Explorations.

scarlet. But to the non-scientific observer it may at once be distinguished from the enemy of the tea plant by the absence of the drum-stick-like process on the back—a structure which may be said to be highly characteristic of **Helopeltis theivora.** I go into these details here so as to dispose of an insect which has so often been mistaken as the possible origin of the tea mosquito, owing to the very *similar* appearance of the leaves punctured by it to those of mosquito-blighted tea. I was also aware that, according to several writers, the wild *pan* **(Piper)** had been recorded as the plant upon which the mosquito lived, when it could not find tea. It may fairly be said that both during my explorations in the Nambar forests and in the jungles around the tea gardens, I examined many miles of country with festoons of this creeper everywhere, yet I never once came across a leaf punctured in any form whatsover, nor could I obtain the slightest indication of a species of **Helopeltis** living on that plant.

TOUR in ASSAM.

Pan Leaves. *Conf. with para. 543.*

In passing it may be said that, as a botanist, I was much disappointed with the Nambar forest. It might almost be described as an impenetrable expanse of some ten or twelve species of lofty trees with a dense undergrowth not very much more varied in character. The soil is, however, remarkably rich and in some parts would be very suitable for tea should an expansion in that direction take place in the future.

11. *Naga Hills.*—From Dimapur I passed to Kohima, and had during the ascent repeated opportunities of studying purely indigenous tea—that is to say, tea regarding which no suspicion could arise (as undoubtedly exists in the case of the plains of Assam) of its being the survival of ancient Native cultivation. It was found on a rich red clayey soil, very similar to the soils in all the more successful gardens of the plains and curiously enough in association with wild *Sa* trees **(Albizzia stipulata)** and stunted bamboos. But what struck me as most significant, I failed absolutely to find any trace of Mosquito, Green-fly, Red-spider, Blister-blight, Red-rust, Grey-blight, Thread-blight, etc., etc., on the wild tea. In fact, with the exception of the older leaves bearing certain lichens and epiphytic fungoid organisms (which are also found on the tea in cultivation near jungle), I could get no trace of any of the pests and blights of the cultivated plant. The stems of the older plants, just as in old tea gardens and seed-gardens, were densely coated, however, with grey lichens. These may

Naga Hills.

***Sa* Tree.** *Conf. with para. 86.*

Absence of Pests on Wild Tea. *Conf. with paras. 45-49, 86, 320.*

Extent of Personal Explorations.

TOUR in ASSAM.

be spoken of as epiphytes, and I think are very unwisely regarded as maladies. At all events, much unnecessary trouble is expended by the planters in the removal of such like epiphytes, while other and far more serious blights are allowed to do incalculable harm.* The grey lichen-coated stem is by most planters spoken of as "hide-bound." But it is a natural indication of age or want of vigorous growth, and if associated with declining yield is a consequence, not a cause of deterioration. All old tea will become lichen encased, and in the wild state the tea plant is more uniformly coated with these epiphytes than is the case almost with any other plant of the jungles in which tea occurs. If lichen or "hide-bound" be therefore a disease of the cultivated tea, every wild tea plant is so diseased, and indeed it might almost be said that the condition known as hide-bound is the only disease of the wild tea plant.

From Kohima I marched north through the Naga Hills to Wokha and Mokokchang until I emerged from the hills once more at Gileki.

Return to Nazira.

12. From the 1st to the 12th of June I re-explored some of the gardens around Nazira in order to check the experiments that I had instituted, and to note the changes that had taken place during the interval of about six weeks of my absence, and on the 8th June I visited Behubar.

13. On the 13th June I proceeded by small steamer down the Dekho river and thence by mail boat to Dibrugarh.

Dibrugarh.

14. *Dibrugarh.*—On the 15th I commenced my exploration of the gardens of Dibrugarh by going to Khonikor, and on the 16th made a passing visit to Chaukidingi; 17th, 18th, and 19th were spent at Panitola with excursions to a good many of the other gardens in that neighbourhood; 20th, 21st, and 22nd, Makum (Margherita); 23rd, went down the river to Namsang; 24th, Jaipur and other gardens; 25th and 26th, Tingri, Balijan and other gardens; 27th, Dum Duma; 28th, Talap; 29th and 30th, Dum Duma (and out-gardens) also Sukerating. July 1st returned to Panitola and proceeded to Dibrugarh on the 2nd.

* If it be thought necessary to remove lichens the plan found most effectual in American orchards should be tried, *viz.*, to paint the affected parts with Bordeaux solution, consisting of 6 lbs. of copper sulphate and 4 lbs. of lime to 11 gallons of water. In a few days the lichens will be killed. *Conf. with paras. 801-3.*

Extent of Personal Explorations.

15. *North Lakhimpur.*—Through the kindness of the Jokai Company I proceeded on the 3rd July, on board their steam launch, to visit some of the gardens of North Lakhimpur. Explored Bordeobam 5th, Patalipam 6th and 7th, Dirpai 8th, but owing to the floods on the Subansiri river, was unable to visit other gardens of this locality, and accordingly returned on board the Jokai steam launch to Biswanath Ghat. **TOUR in ASSAM. North Lakhimpur.**

16. *Biswanath.*—On the 11th July I inspected Gopesadarhu; 12th, passed through Pertabghur and Bor Phukri spending a few hours in each; 13th, Mijikajan; 14th, Giladharee and other gardens near by; 15th, returned to Biswanath Ghat, thence to Silghat by mail steamer and that afternoon inspected Koliabar. **Biswanath.**

17. *Nowgong.*—On the morning of the 16th I drove to Kellyden and spent some hours there, reaching Salonah late in the afternoon. The 17th was spent at Salonah, with a visit to Amluckie in the afternoon. On the 18th I drove back to Silghat visiting on the way Salol and Seconee. **Nowgong.**

18. *Tezpur.*—On the 18th July I arrived at Tezpur and spent the 19th at Borjuli and Sonajuli; 20th, visited Hathibari and Nahorrani; on the 21st returned to Tezpur and reached Calcutta on the 25th July. **Tezpur.**

CHAPTER II.

INDICATIONS OF DETERIORATION.

Conf. with Deterioration, pp. 155-160.

III.—Some General Considerations on Results Obtained.

RESULTS: Unsatisfactory.

19. ***Unsatisfactory Nature of the Explorations.***—It may as well be stated here pointedly that my visit to Kangra was unsatisfactory. I reached the tea gardens too late in the season for seeing the most serious blights. Kangra, moreover, is so free from blights that I would have been in a better position to benefit by my inspection of these gardens had I reached them after having explored the larger and more important centres of the tea industry, instead of commencing operations there. The lessons to be learned from Kangra are more negative than positive, namely, the absence of all the important blights. I shall have occasion, however, to allude in further paragraphs to the pests that were actually met with in Kangra, but it may be stated that the present report is mainly based on my researches in Assam.

Extent of Ground Covered.

It will also be seen, from the statement above of my movements in Assam, that as much ground as possible was covered, during the brief term of my visit to that province. The time allowed me was far too short to admit of any very practical results being attained or scientific experiments performed. Through the kindness of the planters, however, I was enabled to cover on an average from 15 to 20 miles of road travelling daily (in passing from one locality to another), not including the 5 or 6 miles accomplished on foot while inspecting the gardens and hunting for blights. It may further be added that with very few exceptions I never stayed more than 24 hours at any single garden.

Co-operation of Planters. *Conf. with paras. 24, 317(6).*

Though necessarily of a very desultory nature, a certain amount of experience was gained, in thus rapidly inspecting a fairly characteristic set of gardens throughout the province, and of discussing with practical men the many problems of tea-planting that hinge on the subject of blights. I desire, however, to repeat that the present report is submitted chiefly in the hope that it may serve as a basis for more satisfactory operations in the future. The obvious defects of a panoramic view of the problems here reviewed, lies

in the fact that a garden visited in March or April may manifest a condition of affairs entirely dissimilar to that which would prevail in July and still more so in September and October. Moreover, I am assured that the Spring of 1895 was taken as a whole an abnormally bad one for blights of all kinds. Conclusions that are scarcely justifiable by fact are likely, therefore, to be occasionally and unavoidably arrived at on certain subjects, particularly the distribution and seasons of appearance of disease. But such defects may readily enough be corrected in the future, by the vast amount of experience and knowledge that exist, being pieced together, speculations dispelled, and a final report framed that would undoubtedly be of practical value. With the success that has attended the efforts to battle with similar maladies in other branches of agricultural and horticultural enterprise before us, it is no sanguine expectation to affirm that none of the pests and blights of tea, need be regarded as incurable or incapable of being averted. Indeed the wonder is that with so much talk of blight-proof wheats, blight-resistant potatoes, Phyloxera-free vines, etc., etc., no tangible progress has been made in that direction with the tea plant.

RESULTS: Unsatisfactory.

Seasons of Pests.

Pests Curable.

IV.—Treatment of Blights and Pests.

20. *Imported Insecticides.*—The outcry has come from the tea districts for cures without any definite steps having been taken to ascertain the nature of the maladies to be cured. The response has been the supply of certain well-known patent and other insecticide preparations which the planters have been urged to "try." They have done so at considerable loss of time and money. When it is recollected that an acre of tea may contain 2,500 plants or even more, and that most gardens average 500 acres, the larger concerns owning 2,000, 3,000 and even 10,000 acres, it will be seen how impracticable hand syringing with inseeticide fluids must be, even should the poisons employed be quite effectual in killing the pests. Were the entire labour force of a garden to be armed with syringes, the whole estate could not be syringed for many days. By the system of syringing limited plots daily, the portions so syringed become very nearly as badly affected as ever before the whole garden can be overtaken. Moreover, the blights of greatest moment occur when all hands are required to pluck the leaf and when stoppage of that operation for even a few days (in order to syringe) might mean not

TREATMENT of BLIGHTS: Insecticides.

Difficulty in Syringing.

Indications of Deterioration.

TREATMENT of BLIGHTS: Insecticides.

only the loss of the flush then on the bushes but possibly a permanent injury to the flushing power of the garden for the rest of the season. But of course a severe outbreak of blight would no doubt materially reduce the necessity for plucking and thereby liberate a certain amount of hands for insecticide operations. In my opinion, however, insecticides are in the majority of cases impracticable and the labour charge in most cases too great even when, as in the case of an infusion of **Adhatoda Vasica,** the insecticide would cost next to nothing. Were it possible to run carts between the rows of bushes and to thus use larger and more powerful syringes than can be employed by manual labour, the case might be different. But there arises still another consideration, namely, that most, if not all, the insecticides in use are poisons and some of them even contain arsenic.

Poisons.

It is all very well to say that the plants so syringed need not be plucked until after the fall of sufficient rain to wash the leaves clean. But were an insecticide of this nature extensively employed, it would by no means be improbable that some of the poison might find its way into the manufactured tea, moreover its use would undoubtedly endanger the lives of the coolies, and it might even poison the tea bushes themselves. It is quite true that "Paris Green" and "London Purple" have been found effectual in killing certain blights, but it may be said that in no other edible crop* are the leaves the commercial commodity, and therefore that the danger in the use of arsenical preparations is ten-fold greater with this than with almost any other crop seeing that the blights are nearly all leaf diseases.

Useful in Early Stages.

But while such views may be advanced on the subject of an extensive use of insecticides, it should not to be inferred that they are useless in all cases. On the contrary, if employed in the early stages of certain maladies, insecticides very possibly might avert the severity of attack. Sulphur, for example, has been used with success

Chiswick Soap. *Conf. with paras. 736, 742.*

apparently on red-spider and the Chiswick Soap is claimed by its manufacturers to be a cure for all the more serious pests. But I have no practical experience with these or any other insecticides, and mention them simply because of their having been so loudly commended in certain publications. An unfortunate point remains to be added, however, that with mosquito, green-fly and even red-spider,

* Except perhaps Pan and Mulberry.

the pests have advanced so far before being detected that they have even then passed beyond the stage of mitigation.

TREATMENT of BLIGHTS: Adhatoda.

21. ***Indigenous Insecticides.***—Before concluding these general observations on the treatment of blights, and more especially on the subject of insecticides, I have to admit that prior to my visit to Assam I was in hopes an infusion of the leaves and twigs of **Adhatoda Vasica** might be found an effectual remedy against some of the more serious insect pests. The experiments performed by me in Assam convinced me, however, that, while it paralysed the mosquito, it did not act as a direct or immediate poison to that insect. But even had it proved effectual I am now satisfied that it would have been impracticable not merely because of the reasons already advanced against all insecticides, but also owing to special considerations. The mosquito is an extremely active creature and withal remarkably timid. The slightest disturbance to the bush, and the adult or perfect insect flies off, while the immature or wingless ones probably drop to the ground or at all events disappear into the recesses of the crowded central portions of the bush. It is thus very nearly impossible to bring the insecticide into contact with the mosquito, short of absolute submergence of the bushes, and even were that possible the adults would temporarily fly away only to return again with the renewed vigour of whetted appetites. It may be argued that the leaves, with the poison on them, would accomplish the object aimed at, on the return of the insects. Quite so, but that implies that the leaves should be so impregnated with the poison that they could not be used in the manufacture of tea. A poison which would remain on the tea bushes for some days should most certainly be guarded against, since the poisoned young leaves would stand a good chance of being plucked.

Mosquito. *Conf. with para. 559.*

With red-spider **Adhatoda** proved very successful, but not more so than a decoction of muddy water or water impregnated with cow-dung. This tiny insect lives on the upper surface of the leaf, is immediately killed by the **Adhatoda** solution no doubt, but the forcible syringing with pure water has very nearly the same effect. The objection to **Adhatoda** is the same as to all other insecticides, *viz.*, the impossibility of reaching every leaf when, within a few days from its first appearance, this minute creature may be found to have covered the whole tea area. The reader will find further particulars regarding red-spider and the methods of dealing with it, in the special chapter below devoted to that pest.

Red-spider. *Conf. with para. 742.*

Indications of Deterioration.

TREATMENT of BLIGHTS: Adhatoda on Mosquito on Green-fly on White-ants.

While, therefore, my personal experiments with **Adhatoda** on the tea blights have proved disappointing, the reports I have received from many planters have been more encouraging. In one of the gardens visited in North Lakhimpur, the superintendent assured me that, while he failed to discover that **Adhatoda** averted or lessened the attack of mosquito, a plot of badly affected green-fly tea had been completely freed from that pest by its use. He also assured me that in one of the gardens under him white-ants had appeared to an alarming extent. About 2 to 3 gallons of the **Adhatoda** solution had been poured on each bush near the stem with the result that the ants were killed and the bushes immediately showed marked signs of improvement.

22. **Adhatoda** is easily cultivated; a plot of land of 10 to 20 square yards, with the cuttings one foot apart, would afford an abundant supply for all possible needs. This would cost next to nothing. I am, therefore, constrained to urge that, until a more trustworthy body of evidence has been obtained than we at present possess, the use of this insecticide should not be abandoned. Those interested in this subject will find Mr. D. Hooper's Hand-book (Imperial Institute Series) on **Adhatoda,** convenient and useful. Owing to my being editor of the series, under which it appears, I have contributed certain details to Mr. Hooper's Hand-book that might otherwise have appeared in this report, but which need not now be republished.

The poorest soil available, especially abandoned village sites should be selected for **Adhatoda** cultivation. In addition to being a useful insecticide the plant has a high manurial value that should commend it to the attention of planters even were there no other considerations.

Poisonous Fern. *Conf. with paras. 95, 200.*

23. On more than one occasion I was shown a fern—one of the commonest road-side plants in Assam—known to be poisonous * and a decoction of which had been found an effectual insecticide against some of the tea pests. I had not an opportunity of trying this myself, but was assured by two or three planters independently both in Sibsagar and Dibrugarh that they had used it with much advantage. There are in fact many indigenous and abundant plants in Assam that are known to have insecticide properties, and where such preparations are desired I would recommend the use of locally manufactured insecticides to any patent chemical substance of a mineral and inorganic nature,

* **Nephrodium aridum,** *Baker.*

more especially articles poisonous to the higher forms of life as well as to the blights. But in all cases infusions of insecticides should be made up with soap in order to assist in their adhesion.

TREATMENT of BLIGHTS: Soap. *Conf. with para. 786.*

24. ***Agricultural Reforms.***—From the remarks just offered it may be inferred that, as one of the practical outcomes of my Assam explorations, I have been compelled to realize that remarkably little value can be placed on insecticides. In fact, until we have determined the life history of each pest, so as to be able to attack it with poisons, where these are indicated, at the weakest stage of its existence, I regard the promiscuous use of insecticides as pernicious. They certainly result in much loss of interest, and tend to give a feeling of satisfaction that is destructive to further effort. A much famed insecticide has been tried, has proved a failure and therefore nothing further need be thought of. The scheme proposed by this successful planter and that, has been pursued with avidity by his neighbours, only to be followed by a deepening conviction of the futility of averting what must after all be endured and placed against the financial successes on the other side of the record of the garden's operations. The process of trying effects is one of blindly groping in the dark so long as we have no grounds for our experiments. And this state of affairs, as it seems to me, has come about more by accident than anything else. The planters have only to be pointedly told that their co-operation is indispensable to any solution of the complex problems of the tea pests and blights, to ensure a large body of willing and careful observers. The time and money spent in trying experiments with insecticides had far better be directed to an intelligent effort to trace out the habits of pests.

Agricultural Improvements.

Life Histories of Blights.

Co-operation Indispensable *Conf. with paras. 19, 317 (6).*

25. ***Experiments that should be performed in every district.***—Why should we, for example, be unable to say where red-spider hibernates? Some half a dozen simple experiments, extending, perhaps, over two or three years, would solve that point. Is there any occasion that half the planters should say they believe the mosquito hibernates on the tea bushes themselves, while the other half hold that the insect migrates to the jungles for that purpose. Surely, if a few bushes were completely enclosed by fine wire gauze frames, care being taken that some 20 mosquitos or so were placed within each, the return next year of the pest to the bushes or the freedom of the bushes from the blight would remove all doubts on that point.

Necessary Experiments. *Conf. with paras. 108, 274, 277.*

Hibernation of Red-spider,

of Mosquito.

Indications of Deterioration.

TREATMENT of BLIGHTS.
Stunted Blight.
Scientific Investigations.
Conf. with para. 318.

So again the majority of planters maintain that green-fly causes the "stunted blight," but a few hold a very different opinion. Personally I failed to prove the action of the green-fly, but my experiments were unsatisfactory. Need there be any doubt on that point? Two or three bushes, in remote portions of the garden, some that had been severely pruned, others not (but none showing any trace of "stunt" at the time) have only to be carefully enclosed by very fine wire gauze or better still muslin, then a supply of the fly added, when a flood of light would be thrown on the disputed point. Such experiments and many others, if performed independently by planters in different parts of the country, would afford the data upon which might be framed a rational scheme of treatment for the pests and blights.

Consequence not Cause.

26. But I have seen such diversity in the behaviour of most of the diseases of the tea plant that I have had forced upon me the conviction that many of the pests and blights of Indian tea should be relegated to the position of consequences rather than causes of the unhealthy state of the bushes. Where gardens or portions of gardens have been treated liberally and rationally, I have seen remarkably few blights. I could mention many examples of one garden infested with every possible malady, while, hardly a mile off, the outskirts are reached of another garden of equal age, identical soil, exactly similar *jat* of plant, but enjoying an almost complete immunity from blight. Such examples I think very nearly justify the opinion that in addition to exhaustion from age (discussed in another chapter, pp. 155-160) there is an even more serious danger—defective cultivation—so that many of the tea pests and blights will have to be dealt with by changes in the systems and principles of the agricultural operations pursued. Few planters will refuse to admit that certain plots of their gardens are unhealthy, and that the plants are predisposed to the attacks of what may be called external maladies.

Defective Cultivation.
Conf. with paras. 30, 43, 45, 51, 54, 92, 106, 166, 186, 197, 255, 315, 318, 320.

V.—Influences of Cultivation.

INFLUENCES of CULTIVATION: The Wild Plant.
Conf. with paras. 186, 189.

27. ***Botanical Characteristic of Wild Tea.***—It has already been stated that the diseases of the tea plant have very largely originated through cultivation. In the wild state the so-called Assam indigenous tea plant may be described as a somewhat remarkable large bush—in exceptional cases it might even be called a small tree. It rarely forms a pronounced stem, but gives off near the ground, say,

INFLUENCES of CULTIVATION: The Wild Plant.

from 2 feet upwards, three, five, or as many as ten branches which ascend and are sparsely, though similarly, branched, so that the tall narrow bush of 20 to 50 feet in height becomes not unlike a miniature poplar tree. It fruits freely on last year's wood (or near the extremities of the twigs) and the fruits are 1, 2, 3, or 4 seeded with occasionally two seeds within each section of the fruit. The leaves are for the most part not more than 3 to 4 inches long and 1½ to 2 broad. They are of a dark green colour, concave on the upper surface, that is to say, the sides of the leaf ascend slightly so as to form a depression towards the mid-rib. The margins are sharply serrate and the apex considerably elongated. The veins of the leaf when examined by transmitted light show eight primary branches (on either side of the mid-rib) and eight subordinate veins. The veins of one side very nearly alternate with those of the other. The first pair and the last pair are very minute. These sixteen veins arch upwards in loops that unite together a little within the margin. There are often still more subordinate ramifications seen in some forms of the plant, but only the veins that form the loops here mentioned should be counted.

Veins of Leaf. *Conf. with para. 80.*

Recognition of Cultivated Forms. *Conf. with para. 72.* **China Hybrid.**

28. ***Races (Jats) of the Tea Plant.***—The number of the veins is a fairly constant and an interesting feature of the various forms of the tea plant. Thus, for example, it will be found that in the so-called China tea plant, only eight veins loop round in the way mentioned, and in hybrid teas there may be nine, ten, eleven, twelve, thirteen, or fourteen pairs. I do not advance these statements as applicable to every leaf that may be plucked off a tea bush, but I do affirm that the vast majority of the leaves of the "pure Assam indigenous plant" will be seen to have sixteen pairs of veins, "good hybrids" will have from twelve to fourteen, and all "bad hybrids" less than that, while the majority of the leaves of "pure China" will have only eight veins or sometimes even fewer. The "Manipur plant" (and the "Cachar" stock which may originally have been derived from the Manipur) has more than sixteen pairs of veins. In some cases twenty-two veins may be counted. But the Manipur plant has altogether a larger habit than the Assam.

Assam Indigenous. *Conf. with paras. 49, 71-2, 198, 399.*

Manipur.

The Garden Plant.

29. ***Peculiarities Produced in the Garden.***—According to botanists all forms of the tea plant belong to one species. Whether we are to regard the Assam form as a natural race (shall I say variety) distinct from the Manipur or not, cultivation can be seen to have

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produced even greater departures than exist between the very small thick-leaved China stock and the large soft leathery-leaved Manipur plant. Setting on one side the botanical problem here indicated, attention may be directed to the subject of the changes in the character of the tea plant, under the hands of the planter. When grown for its leaf-flushing power it is a bush not more than 4 to 5 feet in height. In some cases a short thick stem, from 4 to 9 inches in diameter and 2 feet in height, has been produced; in others it has been made to branch very early into a skeleton of five or six main branches, each perhaps 2 inches in diameter; and in still another condition a broom of a perhaps 50 to 100 shoots not thicker than the thumb have been made to ascend from the ground parallel to each other to a height of 3 or 4 feet. In all these cases the plant has lost its natural habit of a sparsely branched tall bush. The China plant of the Assam gardens is for the most part a low, much-branched bush which only very occasionally is seen to have a distinct stem. In Kangra, however, it is often tall, erect, and very much more like the hybrid than the China plant met with in Assam.

The Garden Plant.

China Plant in Kangra.

But in addition to a complete change in primary structure or form, it has become densely covered with a multitude of minute branchlets that bear leaves nearly twice the size of the average leaves of the wild plant, and in the better *jats* of Assam indigenous these are pale coloured, soft, less distinctly serrated and concave below. It has to a large extent been deprived of the power of flowering and fruiting,* its whole energies have been concentrated in the flushing or production every seven to ten days (during part of the season at least) of a complete new set of shoots that each bears a terminal bud and three to seven leaves according to the system of plucking that may be pursued. Not only have the leaves become soft and pale green, but, together with the whole of the young shoots, they are very succulent and only slightly lignified.

Flushing. Conf. with para. 206.

30. ***Origin of Disease.***—The entire nature of the plant has been changed. It is of course grown for its young leafy shoots, and success depends on the quantity and rapidity with which these are formed. There is reason to believe that in the early years of tea

Origin of Disease.

Conf. with para. 66.

* Indeed it is considered (and very justly so) an indication of a degeneration, from the planter's standard of a good bush, when it shows a tendency to fruit; the fruits are promptly removed in consequence, but I fear the act of removal could hardly be an effectual cure for this tendency.

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Origin of Disease.

Mid Season.

planting, the Assam indigenous afforded only some four or five flushes* during the season. It now yields on an average from 20 to 30. And if this fact alone does not appeal to most planters as denoting a radical change in the plant, the well-known further fact may be added that for some years past it has been observed that mid season in all good *jat* gardens at least is gradually becoming later. I am aware that some planters think this is due to the plants not being so severely plucked in the early months of the season, a change of practice on that point having taken place owing to the more extended cultivation of Assam indigenous. There may be some truth in that, but still there would appear no doubt the period of the plant's activity is being altered in adaptation to climatic changes (consequent on the opening out of large tracts). It may seem paradoxical, however, to say that success consists in the production and development of a diseased state, but such is the case. The fattened ox is in reality an animal in a condition of disease, quite as much so as blanched celery is a diseased vegetable product. In both cases they could not exist but for the protecting care that is bestowed on them. In other words animals and plants are, strictly speaking, diseased whenever their natural functions are disarranged. In such a condition they can exist when carefully tended only. It might, however, more correctly express this view of the case to say they are in an unhealthy condition and to thus reserve the term "disease" to the specific ailments that supervene. They are, in other words, living in a state of predisposition to the organic diseases that may ultimately effect their destruction.

Diseased State.

Disease a Consequence of Cultivation.

Predisposition. *Conf. with paras. 44, 47, 72, 226, 282, 345, 320.*

31. This is true of course of nearly all cultivation, is in other words an expression of the effects of domestication. But it is doubly true in this case. The tea is forced to produce an abnormal or disproportionate amount of leaf; it has been practically refused the rest given after fruiting; and it has been removed from the shade of the forest and association with other plants. Indeed it seems very likely that the so-called rest that the plant gets in winter is more than obliterated by the annually recurring effort that is required shortly thereafter to recover the severe shock of the pruning (and probably also the deep hoeing) to which it has been subjected.

Domestication.

Winter Rest.

* See Bruce's Reports

Indications of Deterioration.

INFLUENCES of CULTIVATION.
Renewal of Stock.

32. ***Renewal of Stock.***—The stock would undoubtedly be healthier were the tea plant allowed to fruit and die after the lapse of so many years, fresh seedlings being made to take the place of the older and exhausted plants. There can be little doubt that such crops as jute, indigo, and wheat,—crops that are renewed each year from seed,—are by no means so predisposed to disease as are perennial crops grown on the same soil from year to year without any rotation or change in stock. It follows that success in tea-planting must in the end lie in the direction of safeguarding the plant against its predisposition, and that accordingly with the vast majority of the pests and blights prevention must be infinitely better than cure. But the undoubted vitality of the tea plant is such as to have obscured the value of these truisms. Gardens can be pointed out that have given excellent results for thirty or forty years, and a few planters have even assured me that they were convinced such gardens may be expected to continue to do so indefinitely. The superintendent of one of the largest concerns in Assam writes me that in his "opinion old tea when properly treated does not deteriorate." There are, however, many difficulties in the way of trustworthy statistics being compiled on the subject of the possible deterioration of old gardens. Though the manager very likely knows the actual yield of each separate plot, the published returns express the averages for the whole estate. Few gardens are of one age throughout, the majority have had and are now having, new plots added to their leaf-yielding area every few years. Moreover, it would be hard to say that all the plants in any single plot of, say, 20 years' existence were of one age. The habit of filling up vacancies is believed in and carried out by a great many planters. In fact in many of the old gardens there is reason to believe that this practice has been followed and to such an extent as to have practically renewed the greater part of the so-called forty-year old gardens.

Perennial Crops.

Old Tea Bushes.

Renewal by Filling up Vacancies.

Old Gardens: Soil Exhaustion.
Conf. with paras. 35, 54, 108, 114, 128, 144, 157.

The question for the moment may be said to be not one of whether the Assam soil is capable of bearing tea for 40 or 400 years, but exclusively one of the power of endurance of the individual plants. It will be seen under the Chapters below on Drainage and Manures and Manuring that I fully recognise soil exhaustion as an equally serious danger. I have been taken over many estates where no hesitation has been shown in making the statement, "This Company is

practically saved by one of its out-gardens—a bit of excellent land which six or eight years ago was put under the finest Assam *jat*." I am not aware of having been taken over a blighted garden or an inferior portion of a garden, without the apology having been given me that it was "An old garden," a "Neglected bit," or a "Piece ruined by a previous manager." But if the old gardens have done so admirably and have such capabilities still in them, why have we all this outcry for permission to interline and then uproot or for extensions into new areas? Is all that purely and simply the result of the vastly superior yielding power of the "Assam indigenous?" Is there no danger that the plant which stands at present so high in popular favour, after a term of, say, forty years' bearing, may be found inferior to the Burma, Lushai, Japan or some other new favourite? While not desiring for a moment to throw doubt on the merits of the Assam plant, it may be asked,—Is it safe to affirm that no element of the present outcry should be assigned to a very natural deterioration which has taken place as the result of so many years' compulsory leaf bearing?

INFLUENCES OF CULTIVATION: Old Gardens.

New Races.

Deterioration. *Conf. with paras. 971-981.*

If deterioration be admissible, the much-talked-of blights might be viewed as very largely referable to the position of consequences of the present system of cultivation. It can be shown that in most gardens there are maladies present, less visible, it is true, than the visitations of the mosquito, but which are nevertheless permanently injuring the bushes. The effects of these diseases can easily be demonstrated.

33. All well established new gardens admittedly give better results than old ones. This, as already indicated, is doubtless largely due to a better and more productive *jat* or stock being planted out in the new gardens than exists in the older ones. But I was shown over many gardens of the very finest *jats* of tea, the yield of which had declined. I did not come across a garden badly blighted that gave the opposite record. And, with the exception of one or two of the blights and more especially in cases where these blights had only recently appeared to any serious extent, I did not find a garden in Assam badly blighted in which the bushes did not show that they were in an unhealthy state, apart altogether from the peculiar malady with which they were at that particular time beset.

Blights in the Ascendant. *Conf. with para. 166.*

Unhealthy Bushes. *Conf. with para. 166.*

34. There would appear to be no doubt that the number and severity of the tea blights are in the ascendant, and more especially in

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the old than in the new districts. But I speak here of the blights collectively, for I am fully aware of certain pests that attack the finest and youngest tea. These pests are doubtless alarming, but their ultimate effect on the production of the estate is not to be compared with the hundreds of acres that give returns hardly commensurate with the expenditure on them and which are shown to the visitor with an apology for their shortcomings. Personally I would rather own a vigorous garden that was shut up for a few months a year by some endemic pest than one in a chronic state of semi-unproductiveness. The battle against the former is one in which victory must in the end be with the intelligent cultivator, the latter has but one rational course before it—extermination and replanting.

Unproductive Gardens.

Old *versus* New Gardens. *Conf. with para. 274.*

35. It is next to folly to expend money and time in the vain hope of coaxing old, diseased, and unproductive gardens into a state of productiveness. In some cases renovation of the bushes no doubt can be brought about by "collar pruning," but if the stock chanced to be bad originally interplanting better *jats* and uprooting the old bushes would in the end be found more satisfactory, provided the soil has given no indications of exhaustion. I do not go into the question here of the advantages of renewal of stock or filling up of vacancies *versus* extension into new clearances. My present intention is to exemplify the conviction I formed in Assam that by far the most serious diseases are those which slowly but surely and permanently reduce the productive power of the bushes and ever hold over the industry the warning of the Ceylon coffee disease against procrastination in their treatment.

Procrastination Dangerous.

Collar Pruning. *Conf. with paras. 185, 193, 211, 215-25, 272.*

VEGETABLE BLIGHTS.

VI.—Vegetable Blights.

Coffee-Leaf Disease.

36. ***The Coffee-Leaf Disease*** is a fungus that first had attention directed to it in 1868. Prior to that, according to the reports that exist, it had been known to the planters but was not regarded as of any serious consequence. Indeed Nietner, who described some 28 insect and other animal pests of the coffee plant, adds in a subsequent revision of his report, that he had known it for several years, but that it never did any material harm to the coffee until lately. For this reason it was not included in his *Observations on the Enemies of the Coffee Tree*. In my opinion we have similarly been giving a disproportionate amount of attention to the insect and other pests of the tea plant, to the utter neglect of the fungal blights. In 1869 the

For Several Years was Harmless. *Conf. with para. 276.*

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coffee-leaf disease received the name of **Hemileia vastatrix** and it is curiously interesting, as indicating, the mysterious way in which many of the better known fungal blights of crops have made their appearance, that when first examined by the Rev. Mr. Berkeley it was then quite new to science. There was experienced in fact some difficulty in assigning to it a definite place since it was found intermediate in its structural peculiarities to two of the chief groups of parasitic fungi previously known. Though searched for in the neighbouring jungles for some time, the late Mr. Thwaites failed to find it on any of the allied plants to the coffee. It certainly could not have been a prevalent fungus in Ceylon before it appeared on the coffee, since Mr. Berkeley informs us he had examined more than one thousand species of fungi from Ceylon without having had sent to him a specimen of this curious parasite. In 1871 it was, however, discovered on the wild coffee of Ceylon, **Coffea travancorensis**, but whether it had spread from that plant to the cultivated coffee unobserved or had gone in the opposite direction has never been satisfactorily ascertained. In 1878 the Rev. Mr. Abbay read a paper on the subject of the coffee-leaf disease before the Linnean Society which, as affording some useful warnings against any neglect in the treatment of the fungal diseases of the tea, may be here briefly reviewed. "At first, he says, the 'disease' was regarded by those best able to judge as a temporary one, which would run its course for a year or two, and then disappear as mysteriously as it came. This view was strengthened by the apparent departure of the pest when the rainy monsoon came on; but with the return of dry weather it re-appeared. The effect of the disease presently became apparent in a diminution of the fruit which the tree yielded; and in 1872 the matter was regarded as serious. Previous to, and including, 1871, the average yield for five years over the whole island had been 4·5 cwt. per acre, whilst for the five succeeding years the average had *only* been 2·9 cwt." In 1878 the yield became less than 2 cwt. an acre and the average annual loss was estimated at £2,000,000. "Since the 'disease' made its appearance in 1869, the enterprise has suffered to the extent of from £12,000,000 to £15,000,000 in crops alone; yet I believe there is not a single recorded instance of a tree having been killed by the pest." For coffee-leaf disease see Professor H. Marshall Ward's report published in 1881.

VEGETABLE BLIGHTS. Coffee-Leaf Disease.

Not found in the Jungles.

Regarded as Temporary.

Decline in Yield.

Loss £12,000,000.

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VEGETABLE BLIGHTS.

Tea Blights.

37. ***Some Tea Blights.***—What subsequently took place is matter of history and need not be dwelt on here. Without wishing to give this report on Assam tea a tone of alarm greater than the facts that I have been confronted with justify, I am bound to say, that there are fairly prevalent a few fungal blights and one or two insect pests, not hitherto recorded as of serious consequence, that in some respects establish a parallelism to the story of the coffee disease. They have most mysteriously appeared, with one exception have not as yet been traced into the neighbouring jungles, not even to the wild tea, and they are for the most part looked on as curiosities or have not even been recognized as blights. Unfortunately I hold a different opinion. They have certainly hardly as yet given prognostications of any one of them suddenly assuming gigantic proportions, but they are ever present enemies that are reducing the productiveness of the bushes upon which they have become established. I have on more occasions than one marched across gardens this way and that in company with the managers and counted along with them from 25 to 60 per cent. of bushes badly affected by one or other of these blights. They do not kill the bushes (no more than the coffee-leaf disease did at first), but within a few years the plots so affected have to be exhibited with an apology for their shortcomings. I could name a dozen or more gardens that have each a plot of from 50 to 100 acres of fine, large, well-formed indigenous Assam bushes, that a few years hence, if immediate and drastic measures are not taken, will be reduced to distorted unhealthy stumps each bearing a few gnarled and unproductive branches.

Ever Present.

Effect of Blights.

38. And it is the neglect of such blights, very possibly more than anything else, that has brought about the change in productiveness of some of the older gardens. There are few gardens indeed in which one cannot detect here and there a plant affected by one or other of the fungal blights and minute pests to which I allude. In other cases they are more prevalent, particularly in certain plots, but fortunately in only rare instances are they to be found to the alarming extent I have named. I need hardly specialize here these blights, since further particulars will be found in the paragraphs below that deal with them individually.

Thread Blight.

Conf. with paras. 839-60.

39. Two parasites of this nature—one a fungus, the other an alga—may, however, be said to live on the bushes (if not removed) from

Indications of Deterioration.

year to year and to annually destroy a large percentage of the twigs which ought to bear the flushing shoots. These are known popularly as "Thread blight" and "Red rust" **(Cephaleuros virescens*)**. One, if not two, species of fungi live on the roots and extend from bush to bush until their presence is recognized by the death of a circular clump of bushes. So again three, if not four, serious blights attack the leaves for so many months a year and seem thereafter to leave the bushes altogether. These are "Blister blight" **(Exobasidium vexans)**, "Grey blight," and a curious disease which I think must be accepted as a felt-mite **(Acarus sp.)**. I have given to this insect pest the provisional trivial name of "Apple-foliage blight" on account of the more or less permanent structural changes which it effects on the leaves.

VEGETABLE BLIGHTS:
Red Rust. *Conf. with paras. 851-874.*
Blister Blight. *Conf. with paras. 818-96.*
Apple-foliage Blight. *Conf. with paras. 759-79.*

40. The last mentioned does not seem to have been recognized by the planters as a blight at all. The fact that the plants affected by it *never flushed, had been observed by nearly every one. These plants* have for the most part been regarded as sulking, though in some cases individual bushes had been observed for many years to have remained in the same state without giving a single leaf in return for the cultivation and even manure that had been expended on them liberally. I believe most of the gardens in Sibsagar district, where this disease seems to be worst, contain from one to five per cent. of bushes affected in the manner here indicated. But in addition to this felt-mite there are several species of blister-mites distributed all over the tea estates. The leaves are pale coloured and on the under side show multitudes of minute warts.

Prevalent in Sibsagar.

41. The term "Grey blight" I have given to a fungal leaf disease **(Pestalozzia Guepini)** of increasing frequency and severity that has been observed by many planters as doing considerable injury. It seems to have first appeared in the Dibrugarh district, but has within the past few years spread over the greater part of Assam. The leaves become blotched with grey patches on the upper surface. These commence for the most part at the base, more rarely the apex of the leaf, and extend until the whole surface is covered. Each leaf, as the disease advances, drops into contact with a leaf below, and where it so touches becomes fused with a woolly-like structure that

Grey Blight. *Conf. with paras. 804-18.*
Originated in Dibrugarh.

* Formerly known to Indian Planters as **Mycoidea parasitica.**

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VEGETABLE BLIGHTS: Grey Blight.

is seen to at once communicate the disease. The injury spreads rapidly until a zone of, perhaps, a foot in diameter has passed round the circumference of the bush. Not infrequently it extends upwards as well and the bush then becomes entirely denuded of its leaves. But curiously enough the action seems often to be suddenly arrested, so that bushes may be found partially or entirely denuded of their foliage or only a large patch on one side of them may be so affected.

Wind Distributed.

The malady appears also to be carried by the wind since across certain plots all the larger or exposed bushes become at first affected and on the same side. But this fungus not only destroys the leaves, it attacks the buds as well, so that when the bush throws off the attack and bursts into fresh activity, it is seen to have large gaps or holes, caused by the twigs that have perished. In some respects it resembles thread-blight, specially in the woolly attachment that communicates the disease, but there is no thread extending down the twigs, and the upper, not the under, surface of the leaf is invaded by the fungus.

Blister Blight. *Conf. with paras. 818-26.*

42. "Blister blight," which at first I thought might not be of fungal origin, but possibly a gall-forming mite, allied to that which causes the blisters on the leaves of the pear tree (**Phytoptus pyri**) similarly attacks the leaves. There is, however, no doubt as to its being of fungal origin. It exists as large shining circular depressed blotches above, which below seem as if they were coated with white wool. When first seen it appears as a minute pink spot with a gradually expanding transparent pale green margin. In two months' time all the affected leaves and twigs turn black and die.

Bushes turn Black.

The bushes then recover and the planter may be disposed to think the blight has disappeared and may even imagine from the renewed activity of the plants that it has done no material injury. At the same season, however, it will very possibly return once more and again close large portions of the garden, though it need not necessarily commence on the same bushes on which it first appeared last season. Of one garden I was told of two attacks, one in Spring, the other in Autumn. Can it, therefore, be said that experience, in other parts of the world, supports the affirmation that since blister only appears in Spring it is not serious although it may close the garden for parts of March, April and May? But even were this of no great consequence, have we any evidence that blister may

not change its habit and come at two or more seasons? It has already been reported to have done so in at least one garden.

VEGETABLE BLIGHTS:
Tea Blights.

43. It will be seen, from the further particulars recorded below, regarding these animal pests and vegetable blights, that in the first instance they almost invariably attack tea of a particular kind or in a certain stage of growth. They have not as yet been found on wild, that is, indigenous tea in the jungles, and therefore there would seem no doubt they find in the cultivated states of the plant the peculiar conditions necessary for their production. There would appear abundant evidence that many of these diseases cannot in any way be treated with insecticides, but may yield to improvements in the system of pruning, more especially a change in the season of pruning, to suit special diseases. In some instances they are associated with imperfect drainage, in others occur for the most part in small confined plots surrounded with jungle, or bad ventilation, in still another condition, appear on young vigorous shoots in the early months of unpruned tea. But the inference, as I have already said, seems to me unavoidable that in many instances the peculiar conditions of cultivation and the character of bush and leaf, which the planter aims at producing, are peculiarly the hot-beds of many of the most serious diseases of the tea plant. This statement will be again returned to and substantiated in the Chapters on Pruning and Plucking.

Preferences Manifested.

Change in Season of Pruning.

Hot-beds of Disease.

VII.—Insect and other Animal Pests.

INSECT PESTS.

44. The publication of this report has not been delayed until the scientific determinations of all the blights and pests had been accomplished, because I deem the general principles involved by the study of these of even greater consequence. This defect compels me, however, to speak, for the present, in terms of uncertainty regarding some of these maladies. There would seem no doubt that the prevalence and the wide distribution of most of the pests indicate that cultivation has produced a condition of predisposition to these attacks. This idea could not be more clearly established than by a study of the better known insect pests of the tea plant. It might, almost without fear of contradiction, be affirmed that the majority of the herbivorous insects of the Assam valley have shown, or are showing, a willingness to live on some part of the tea plant such as the leaves, buds, flowers, bark, root or wood. The great majority of these pests do so very

Predisposition.
Conf. with paras. 31, 47, 99, 226, 282, 315, 390.

Indications of Deterioration.

ANIMAL PESTS.

little harm, however, and have given so little indication of their ever being able to do much more injury than at present, that the interest in them centres mainly in the indications they afford of cultivation having altered or weakened very materially the nature and properties of the tea plant.

Common to Coffee and Tea.

45. ***Common Pests of Coffee and Tea.***—Botanically tea is not so near related to coffee as it is to several of the indigenous bushes that are prevalent in the jungles around the gardens. **Eurya japonica,** for example, is not only a bush readily mistakable for tea, but it might be described as cousin to it. The coffee plant is not a native of Assam and is only experimentally grown in one or two gardens. There is, however, a wild species of the genus common all over the province **Coffea bengalensis.** The so-called wild coffee of many persons in Assam is a **Morinda,** and, therefore, not coffee at all. The indigenous coffee plant is leafless for more than half the year. I have examined it with great care, but never found on it any of the tea pests. Yet strange as it may seem, a very large percentage of the insect pests of the Ceylon coffee plant, as described by **Nietner** have been found doing considerable damage to tea in India.

Not Traced to Wild Plants.

Few, if any, of these common pests of coffee and tea have as yet been traced to other plants in the Assam jungles, and the problem thus presented for solution is one of great obscurity. Insects, as a rule, are remarkably accurate botanists. In the jungles the majority will be found to confine their predatory habits to certain species of plants, sometimes even to certain varieties of a species,—omnivorous insects (that is to say, insects that will feed on different plants) are met with more frequently under cultivation than in the jungles.

Mosquito-like Puncturings.

The scarlet insect that has been alluded to as puncturing the leaves of **Mæsa indica** is not likely to be found on any other plant. When eight or ten of these insects were confined on tea shoots, they refused to puncture them and most of the insects accordingly died of starvation, the others recovered directly they were given a supply of their own peculiar food. I have examined carefully all the plants of the Assam jungles that are allied to the tea (such as **Eurya, Schima,*** etc., and even **Camellia thea** itself, in its wild habitat, but never succeeded to find any of the tea pests on these. Similarly I have looked at the bushes and herbs of these jungles that are allied to

* See the remarks under the account of Mosquito, paras. 513-14.

coffee, but equally failed to find on these the insects that have been recorded as common to both coffee and tea.

ANIMAL PESTS: Common to Coffee and Tea.

46. Nietner (*The Coffee Tree and Its Enemies, Edition by Green, 1880*) describes 27 insect pests on Ceylon coffee, and of these (or closely allied forms) some ten or eleven are found on tea in India. It may be of interest to record here the names of these corresponding Coffee and Tea pests.

Brown Bug. *Conf. with paras. 648-49.*

(1) **Lecanium coffeæ**, *Nietner* (the brown scaly bug), found by me in North Lakhimpur, Nowgong, etc.

(2) **Lecanium nigrum**, *Nietner* (the black bug); said to occur in Kangra. And in association with these two bugs (just as in Ceylon) a black fungus is met with (? **Triposporium Gardneri**, *Berk.*) living apparently upon the saccharine secretions caused by these insects.

Fungi. *Conf. with paras. 638-9, 801, 837-8.*

Black Aphis. *Conf. with paras. 597-610.*

(3) **Aphis coffeæ**, *Nietner*, represented in Kangra and Assam by the allied insect **Ceylonia theæcola**. This curiously interesting creature occurs in every tea garden in Assam, and on one occasion I found it in the jungles feeding on **Mæsa indica.**

Red-spider. *Conf. with paras. 718-48.*

(4) **Tetranychus bioculatus**, *W.-M.* (the Red-spider), described by Nietner as **Acarus coffeæ**. Found by me once or twice on rose bushes, in flower gardens, and on the flowering **Camellia.** Never seen in the jungles. It seems to have become diffused throughout the tea districts of the world. I found it, for example, in a new garden, in the Dibrugarh district, that has at least 20 miles of jungle all round separating it from other tea gardens. Could it have been imported by rose bushes?

Red-borer. *Conf. with paras. 393-398.*

(5) **Zeuzera coffeæ**, *Nietner.*—The Red-borer, common in Assam and Kangra, though in neither of these centres assuming alarming proportions.

Stinging Caterpillars. *Conf. with paras. 399-416.*

(6) **Parasa lepida**, *Moore* (the Indian form), described by Nietner as **Limacodes graciosa.** This moth exists in the larval stage as a stinging caterpillar of a greenish colour; and if not itself present in Assam one or two allied species take its place.

Cut-worm. *Conf. with paras. 451-53.*

(7) **Agrotis? suffusa**, *Fabr.* (representing the Ceylon coffee "Cut-worm," **A. segetum**), was found in one or two nurseries eating the roots of the young tea. The determination of this moth may be regarded as open to doubt.

Leaf-roller. *Conf. with paras. 469-73.*

(8) **Gracilaria theivora**, *Wlsm.* This insect is common on the tea both in Ceylon and in Assam and is a pest of considerable

ANIMAL PESTS: Common to Coffee and Tea.

importance. The larvæ in their early stage travel beneath the under-epidermis of the leaf, generally in the direction from the mid-rib to the margin. They then emerge and cause a fold of the margin, perhaps an inch in length and less than a quarter in breadth to roll over them. In a further stage they roll the leaf more or less completely from apex to base, doing considerable injury to the tea where they are met with at all plentifully.

Leaf-borer. *Conf. with paras. 491-93.*

(9) **Oscinis theæ**, *Bigot.* This is an extremely common insect in Assam; in most gardens it is not difficult to find a bush that has one or more of its leaves burrowed by the larvæ of this minute fly. The action appears to commence near the base of the leaf and is carried to the apex where the chestnut-coloured cocoon may be readily seen.

White-ants. *Conf. with paras. 665-710.*

(10) **Termes taprobanes**, *Walker* (the common white-ant of India), the **T. fatalis** of **Nietner's** Ceylon coffee pests, often does much harm to tea.

47. Doubtless when the study of the tea pests has been prosecuted more satisfactorily than at present, other examples may be found. But those mentioned may be held as supporting the view that is here desired to inculcate, namely, that cultivation of the tea plant (just as is the case of the coffee) has brought it into a condition of predisposition to the attacks of blights and pests. It is curious, however, that two so widely dissimilar plants as tea and coffee—the one grown for its leaf and the other for its seed—should have resulted in bringing them into a condition favourable to so many pests in common. This may of course be due to the active principle of coffee and tea being chemically so very similar, if not identical.

Predisposition. *Conf. with paras. 30, 92, 226, 282, 320.*

Indian and Ceylon Tea Pests.

48. ***Common Pests of Indian and Ceylon Tea.***—It is even more remarkable still that throughout the Indian and Ceylon tea areas so large a proportion of the tea pests should re-appear again and again in localities often remote from each other and which possess but little in common save the existence of the tea plant. **Mr. E. E. Green** has published in the *Ceylon Independent* several very admirable papers on the subject of the tea pests of Ceylon. These have re-appeared as a useful little book called *The Insect Pests of the Tea Plant.* **Mr. E. C. Cotes**, formerly an assistant in the Indian Museum, issued some two years ago, in the *Museum Notes*, a review of the literature of the Indian tea pests, in the possession of the Indian Museum.

The explorations conducted by me in Kangra and Assam have not only brought to light a large number of new tea pests, but have revealed the fact that a very much more extensive series of the Ceylon ones occur in India than was previously thought. Mr. Cotes, for example, describes some 40 species of tea pests, and of these 18 have not been recorded as met with in Ceylon; two species mentioned by Mr. Cotes seem peculiar to Ceylon; and the balance are either mentioned by Mr. Cotes, as common to both India and Ceylon or are species hitherto recorded in Ceylon only but which, it will be seen in another chapter of this report, have now been added by me to our list of Indian tea pests.

ANIMAL PESTS: Indian and Ceylon Tea Pests.

49. When it is recollected that some of these, such as the mites, are so minute that they cannot be seen by the naked eye, the marvel is presented not only of their existing both in India and Ceylon, but of their being capable of moving with rapidity from district to district within India itself. Mr. Green speaks of the mite mentioned below (which I take to be very possibly one of the species of mites recently found by me in India) as having been detected in certain Ceylon nurseries.

Mites.

Migration of Pests.

Although not hitherto recorded in India a minute mite closely allied to, if not identical with, the species described by Mr. Green as **Typhlodromus carinatus** was found by me all but universal in Assam in association with another mite—an undescribed species which I have called the pink-mite—**Phytoptus theæ.** The latter is possibly the chief cause of the late flushing of the purer Assam *jats* of tea, and what struck me as significant, it had (like the red-spider) found its way to all the new gardens and in one case to a garden opened out only four years ago in a district where no other estate occurs nearer than 20 miles in any direction. I looked very carefully for this mite in the jungles around the tea gardens, but failed absolutely to detect it, though, from March to June, the characteristic pale green leaf of Assam indigenous tea, plucked from a very large proportion of the gardens, if viewed under a fairly powerful lens, would be seen to be literally alive with this very minute enemy to the planter.

Purple-mite. *Conf. with paras. 747-58.*

Pink-mite. *Conf. with paras. 780-95.*

Late Flushing. *Conf. with para. 785.*

VIII.—Influence of Jats of Tea on the Development of Blights and Pests.

JATS OF TEA in RELATION to BLIGHTS and PESTS.

50. *Cause of Late Flushing.*—The circumstance mentioned above will no doubt come as a revelation to many planters, since the

JATS of TEA in RELATION to BLIGHTS and PESTS.

opinion that the pale colour of Assam indigenous was an indication of the high quality of the *jat* is all but universally held. I do not for a moment wish it to be understood that I deny that the Assam indigenous races collectively are not naturally pale coloured perhaps more so than the Cachar and Manipur, and I am not unaware that within the series of forms (or *jats*) designated "Assam indigenous" there are recognizable shades of colour. Singlo is for the most part paler coloured than Bazaloni or Namsang. But what I do contend for is that there is very commonly seen in gardens of Assam indigenous, a greater degree of paleness than is natural, and that this abnormal paleness is associated with exceptionally late flushing. It occurs more especially in seasons of drought and late rains, on plots of land that become flooded in the rains and caked in the dry weather, or that are too exposed and dry for Assam *jats*. The leaves will be seen to be not only pale green, almost straw-coloured, but to have a pink tinge, especially along the margins and veins. Later on in the season they become spotted, bronzed and very brittle, and, although they do not fall off, the bushes have been distinctly arrested in their growth and the buds even rendered unproductive or "*banjhi*." This state of affairs is undoubtedly caused by the pink-mite, and, although its presence has never before been recognized, it is in many respects a more serious visitation than the much-talked-of red-spider, because of its attacking the young tea and the better *jats*.

Singlo. Bazaloni. Namsang.

Pink-mite.

Banjhi. *Conf. with paras. 79, 206, 230.*

51. Though searched for carefully I failed to find the pink-mite on China tea or even on hybrid *jats*, unless when these approached very closely to the Assam types. Here then we obtain an indication that cultivation has not only changed the character of the tea plant, but that there have been produced special conditions that are more favourable to one set of blights and pests than to others; or it may be, that give a degree of immunity from certain diseases.

Cultivation: Effects of.

I am not prepared to affirm that the success that has been attained by some gardens, with Manipur stock, is due very materially to the fact that I have found this mite much less frequent on the Cachar and Manipur *jats* of tea than on the pure Assam indigenous. Indeed I have reason to believe that the pink-mite is not unknown even in Cachar gardens, presumably of Cachar stock. But I hold emphatically that it is most unwise to purchase a particular *jat* of seed, on the high reputation ii enjoys, without reference to its suitability or

Immunity of Manipur Stock.

otherwise to the conditions under which it is proposed to be cultivated. We know enough to begin to piece together some elementary facts regarding each of the better known races of the tea plant, and among these should undoubtedly be included the liability of the Assam indigenous to the ravages of the mite here alluded to, on all soils that do not retain sub-soil moisture or that suffer from lateness of rainfall. **JATS of TEA in RELATION to BLIGHTS and PESTS.**

52. ***Hybrid more liable to Mosquito.***—So again the hybrid teas are known to flush early, are in many cases hardy, give a rich flavour to the teas, and yield favourable results in gardens where the purer *jats* have, comparatively speaking, failed, but my own observations confirm the very general report that mosquito makes its appearance first of all upon the hybrids. It is certainly remarkable that the newer gardens that possess next to no hybrids enjoy a comparative immunity from this—by far the most serious insect pest of the tea plant. But in 1881, according to the late Mr. Wood-Mason, it was chiefly found on the China plant and had never been seen on the indigenous. It has since that date apparently changed its habit, for it may be found on all forms, though preferably on the hybrids. But in some gardens where it may be said to have only recently appeared, the mosquito still shows its preference for the China plant. **Flushing Early.** **Liability to Mosquito.** **Change in Habitat.**

53. ***China and Hybrid first attacked by Red-spider.***—In a like manner red-spider appears first of all on China and poor hybrid teas, rarely on Assam. It is the first to appear of all the serious pests in point of date, and a concensus of opinion was given me that seemed significant, *viz.*, that in the early part of the season it was first observed on the bushes near the lines or other buildings within the garden. I do not deal here with the practical considerations that may suggest themselves from that observation, since my present object is to endeavour to set forth the indications that support the opinion that certain *jats* of tea are more liable to, or enjoy a comparative immunity from, certain blights. But if the illustrations already given be accepted as sufficient justification (and many more might be mentioned), then the affirmation may be made that some practical steps to improve the seed and, if possible, to produce blight-proof *jats* of tea, is one of the most imperatively demanded reforms of the industry. **Liability to Red-spider.** *Conf. with para. 789.* **Blight-proof Seed.** *Conf. with para. 79.*

54. ***Conclusion.***—Having thus very briefly brought before the reader some of more general considerations that would seem to justify the inference being drawn that, during the past half century **Conclusion.**

Indications of Deterioration.

CONCLUSION.

of cultivation, many very remarkable changes have taken place in the properties and disease-resisting powers of the Assam plant, I need hardly add that the problem, to my mind, that presents itself for consideration is more one of methods of prevention rather than of cure. In a further part of this report, I shall endeavour to set forth all I have been enabled to discover regarding each of the chief maladies of the crop, but the final conclusion arrived at, from the study of these pests and blights, is, I presume, of greater consequence than pure scientific details. That conclusion may be stated briefly, that reforms in the selection of seed, better systems of tillage, more rational pruning and less severity in plucking, would bring about improvements in the health and yielding properties of the plant, of a far greater and more lasting character than could be accomplished by the discovery of methods of curing one disease after another. To effect a cure, without the removal of the predisposing conditions, would, in all probability, be in each case to prepare the way for another and perhaps a more disastrous enemy. I do not, however, wish it to be supposed that there is no occasion to study the diseases, nor to attempt to work out the life histories of the parasites to which the plant has become liable. The surest indication of defects in soil or in cultivation, will unquestionably be obtained by a study of the enemies of the plant. But even when methods of improvement have been fully established, it would still be necessary to eradicate parasites, so that the study of the pests and blights of the plant must be looked upon as an imperative obligation laid on every practical planter.

Prevention Better than Cure.

Pests as Indicative of Defects in Cultivation.

Conf. with paras. 30, 43, 45, 51, 92, 106, 166, 186, 197, 255, 315, 318, 320.

With these remarks it may now be desirable that I should attempt to exhibit, one after the other, some of the more important features of tea-planting that I regard susceptible of improvement.* I would crave the indulgence of the reader, however, for any mistaken conceptions I may have fallen into, and by way of apology for my shortcomings would offer the reminder that my knowledge of the subject may, in perfect fairness, be characterised as acquired during a ride of two months' duration through the tea districts of the province of Assam. Personally I should have preferred to delay publication until I had had further opportunities of verifying or correcting my impressions; but it has been thought that a statement of my views, however immature, might nevertheless be useful as indicating the direction investigation might now take and probably as originating a more liberal exchange of ideas and experiences than we at present possess.

Extent of Personal Explorations.

Conf. with paras. 2, 55, 92, 316.

NUTRITIVE and REPRODUCTIVE.

CHAPTER III.

PLANT LIFE.

55. While fully conscious that it would be both undesirable and unsatisfactory to attempt in a few pages a scientific account of even the leading features of Plant Life, it may serve a useful purpose, nevertheless, if I endeavour to bring to mind some of the leading facts that should guide the tea-planter in his out-door operations. I shall, therefore, only touch on those aspects of this very instructive study that have a direct bearing on Hoeing and Weeding, Draining, Pruning, Plucking and Manuring. It should accordingly be understood that the few brief paragraphs that comprise this chapter have been offered with one object, namely, to help to elucidate certain practical recommendations which I feel called upon to lay before those interested in tea-planting. My remarks must not, therefore, be judged according to the standard of advanced research into the physiology of plants.

PLANT LIFE. *Conf. with paras. 117, 186.*

IX.—Nutritive and Reproductive Systems.

56. ***Parts of the Plant.***—It is customary to speak of the parts of a plant as consisting of two sets, *Nutritive* and *Reproductive*. The former are concerned with the life of the individual, the latter with the perpetuation of the species. The nutritive organs may be said to be the Roots, Stem, Branches and Leaves ; the reproductive, the Flowers and Fruits with their ultimate offspring—the Seed.

Nutritive and Reproductive Functions.

Although not absolutely correct, it may be said that the roots are the mouths of the plant, and that the leaves are both the lungs and the stomach. The food of plants may be expressed briefly as Air, Water and Mineral Substances. The atmosphere being but indirectly under the control of the agriculturist, his attention is mainly directed to the soil. Under the Chapters on Hoeing and on Draining, an effort will be made to indicate the manner in which the cultivator may take full advantage of the valuable properties of air. By drainage, moreover, not only can the soil temperature be raised, but even climatic conditions beneficially influenced.

Mouths of the Plant.

Food of Plants.

Value of Air.

Air may be regarded as consisting of Oxygen and Nitrogen, two gases that are intimately mixed up but which remain chemically free

Composition of Air.

Plant Life.

NUTRITIVE and REPRODUCTIVE.

Nitric Acid.

from each other—a wonderful fact and one of the greatest importance. During thunderstorms, however, actual union takes place between a certain amount of these two gases, and a compound results which by a further union with the elements of water becomes Nitric Acid. That acid is of the greatest value to the plants since it contributes toward the decompositions of the soil by which insoluble substances are rendered soluble. But the air also contains a very considerable amount of Carbonic Acid gas, and a lesser amount, of an equally valuable compound, Ammonia.

Respiration. *Conf. with para. 61.*

57. ***Respiration.***—Animals inhale the air in order that its free oxygen may be combined with the waste carbon of their bodies forming carbonic acid, and this is exhaled. Plants breathe by precisely the same principle, but added to their respiration they have a process of digestion. Under the influence of the light rays of the sun, acting on the green colouring matter of the leaves, the carbonic acid of their exhalation, as also the carbonic acid of the atmosphere, is decomposed, the carbon retained as a food material, and pure oxygen exhaled. During night, however, this absorption of carbon does not take place, so that the respiration of plants is then demonstrable as identical with that of animals.

Chlorophyll. *Conf. with para. 60.*

Food Materials.

58. ***Food Materials.***—The food of animals has to undergo a regular series of chemical changes collectively designated *Digestion,* before it can be absorbed or utilized. Moreover, the food materials of animals are very different from those of plants, since animals are unable to live upon earthy or inorganic substances. The animal is in fact entirely dependent on the plant for the preparation of its food. Plant food may be said to be oxygen, hydrogen, nitrogen and carbon, (all derived from air and water) also certain earthy materials obtained from the soil. The plant possesses no stomach strictly so speaking, but nevertheless its food materials have to undergo chemical changes, by a process designated *Assimilation,* which closely corresponds to digestion, before they can be built up in the tissues of the plant. Although the proportion of mineral matter eaten by plants is comparatively small, the higher plants at least cannot live without certain mineral substances. Each plant may be said to demand certain inorganic substances, otherwise it will not grow. The agriculturist, in his efforts to improve the soil, has, therefore, to direct attention chiefly to these indispensable inorganic food substances. During the process

Assimilation. *Conf. with paras. 58-64, 117, 183-4, 245, 268, 297.*

of assimilation the food materials are built up into various organic compounds, and these again are utilized in the formation of plant tissues. Briefly, the organic compounds of plants may be said to be :— **NUTRITIVE and REPRODUCTIVE.**

Chemical Compounds of Plant Tissue.

1st.—Starches or compounds built up of oxygen, hydrogen and carbon, in varying proportions. Of this nature may be mentioned starch proper; cellulose or the constituent of wood and fibre; gum; and, lastly, sugar.

2nd.—Gluten or the Protein compounds. These contain nitrogen in addition to the oxygen, hydrogen and carbon of the starches, as also smaller proportions of sulphur, phosphorus, etc. Of this nature may be mentioned gluten proper; albumen; casein, etc., etc.

All living and growing vegetable tissues contain a certain proportion of protein matter and a liberal supply of nitrogen is, therefore, indispensable to the life of plants. Let it be added in passing that nitrogen may be regarded as derived mainly, if not entirely, by the roots.

3rd.—Oils or Fats.—These all agree in containing less oxygen than would be necessary to convert their hydrogen into water.

4th.—Water, an article of food the elements of which are occasionally separated and utilized in the formation of certain compounds.

X.—Circulation of Sap.

CIRCULATION. *Conf. with paras. 59-64, 118, 231.*

59. ***Growth.***—On placing a seed under the conditions of germination the first change that takes place may be said to be that a portion of its protein undergoes a sort of putrefaction by which it is converted into a substance very generally designated—*Diastase*. That substance is no sooner produced than it acts upon the store of starch (also contained within the seed) and converts it into a form of sugar, which being soluble thus increases the specific gravity of the cell contents. *Osmose* is in this way brought into action, that is to say, water is absorbed. It passes through the component cell-walls of the seed, obedient to a law of nature that a balance must be at once struck, should the specific gravities of two adjacent fluids be disturbed. **Growth.** **Diastase.** **Law of Osmose.**

Plant Life.

CIRCULATION of SAP.

60. The latent embryo being thus supplied with soluble food materials commences to grow. No sooner has its young stem and leaves ascended above ground than their cells become charged with a green colouring matter (*Chlorophyll*) the services of which are now eminently required. With the exception of the moisture and the small amount of soluble substances absorbed, growth hitherto must be viewed as simply the result of the embryo having been able to use the materials which had been stored up for it within the seed. It may in fact be defined as growth the result of re-arrangement. But no sooner have the roots penetrated the soil and the leaves unfolded in the atmosphere than three distinct phenomena make their appearance :—

Action of Chlorophyll.

Growth.

1st.—The sun by evaporation withdraws moisture from the leaves and thus the specific gravity of their cell-contents becomes increased owing to concentration.

2nd.—The leaves commence to breathe and purify thereby what may even already be impure.

3rd.—The leaves decompose the carbonic acid of the atmosphere inhaled by them, retain the carbon and set free the oxygen.

61. ***Ascent of Sap.***—For convenience we may view these conditions as originating the circulation of the sap and commencing the process of assimilation. It has been stated that by osmose the specific gravity of the cell-contents of the delicate roots that had emerged from the seed, was lowered. But by transpiration from the cells of the leaves, the specific gravity of *their* cell-contents is now raised. In consequence the cells above draw on the cells below for an extra supply of moisture. This suction from above and osmotic pressure from below may thus be viewed as sufficient to originate a circulation of fluid through the plant tissue. The ascending current is called the *Crude Sap*, because, while it contains many of the necessary food materials, they exist in a condition that cannot be utilized. The crude sap has to undergo a series of changes which, as already stated, are collectively designated the assimilation or digestion of plants.

Ascending or Crude Sap.

Water.

62. But let us see what the crude sap contains, before we proceed to discuss the changes of assimilation. Water of course constitutes by far its largest proportion and is in addition the medium, through

which other substances have been absorbed—for the food materials of plants must be soluble. Held in solution, then, the crude sap contains nitrogen and nitrates. These nitrates have been derived from various sources, such as the ammonia of decomposing organic matter and of the air, nitrates formed by the nitric acid of the air, and last but perhaps the most important of all from the nitrating organisms of the soil which originate chiefly from the roots of leguminous plants. Lastly, the crude sap contains the mineral substances derived from the soil.

CIRCULATION of SAP. **Origin of Nitrates.** *Conf. with para. 296.* **Nitrating Organisms.** *Conf. with paras. 165, 285, 297-313.*

63. Avoiding all controversial points, it may not incorrectly then be regarded that the current of water, laden with these food materials, ascends through the young layer of wood, immediately underneath the bark, being propelled by the following amongst other forces:—osmotic pressure below, suction due to transpiration above, the chemical affinity that the cell-walls possess for water, capillary attraction between layers of cells and tissues, and, lastly, the decomposition of water and the utilization of its component elements during assimilation.

Position of Current. **Motives of Circulation.**

64. ***Assimilation and Descent of Sap.***—By whatever means it *may be*, this is certain, that a steady current of sap ascends amongst the young wood cells and, on reaching the leaves, is acted on in the three ways already mentioned. It is concentrated by perspiration, it is purified by respiration, and it is carbonised by decomposition of the carbonic acid gas of the atmosphere. This carbon entering into combination directly with the elements of water, forms one or other of the soluble starches. By union with water, with carbon and with a nitrate, protein matter is produced. In this way, then, many nutritious food-stuffs are formed. The sap is now digested or as it is called assimilated, and it slowly makes its way downwards by diffusing itself through the entire substance of the plant. From the elaborated *Descending Sap* the various tissues and structures are able to pick out the compounds which they require and these built up within the cells, cause them to grow, and finally, when mature to multiply, so that with vigorous circulation of sap rapid growth takes place.

Assimilation. **Agents of.** **Descending or Elaborated Sap.** **Position of.**

XI.—Conditions of Maturity.

Plant Structures.

65. ***Plant Tissue.***—The cell may be said to be the ultimate structure. It is a small sac, the containing wall of which is composed of

Plant Life.

CONDITIONS of MATURITY.

cellulose. One of the most striking peculiarities of the cell-wall has already been mentioned, but may be here more pointedly recapitulated. Although devoid of pores of any kind, fluids pass freely through in obedience to the law of osmose. The cell-contents are of a liquid nature with sometimes solid materials formed within.

Many microscopic plants consist simply of one cell. Others are built up of cells all of one shape and size, like the bricks of a wall only that they are living bricks that increase in number by cell division. In still a third class of plants the cells are of different shapes, many compacted together and even fused, end on end, into tubes that ultimately form fibrous tissue and wood. These changes in the shape and also in the special adaptations of the cell, are brought into existence in obedience to the demand for the accomplishment of fixed and definite functions, attributed to the various organs of plant structure. The walls of the cells are thickened when the object is to form wood; the cell-walls in that case gradually become impervious to fluids and thus cease to participate in the circulation of sap. Wood is, therefore, developed to give strength and support to the young growing shoots and to bear the flowers and fruits.

Formation of Wood.
Conf. with paras. 176, 183, 186, 190, 199, 205, 225.

66. ***Reproduction.***—But the formation of wood, beyond certain limits, when the object aimed at by the cultivator is a free circulation of sap and rapid production of shoots, may be regarded as an unfavourable and undesirable symptom. It is an unmistakable sign of the advance of age and will assuredly be followed by the production of flowers and fruits. When, therefore, a plant has attained maturity, reproduction becomes the governing principle of its future life. Should it be prematurely aged, by adverse circumstances, it may similarly be seen to put forth an effort to make up for the fast approach of its own death by the production of the germs for a new generation.

Production of Flowers.
Conf. with para. 29.

XII.—Practical Lessons to be Learned.

Continuous Growth: Flushing.

67. ***Continuous Growth—Flushing.***—To the tea-planter, therefore, the production of wood or of flowers should be looked upon as untoward circumstances. In both cases pruning becomes a necessity. But pruning must go hand and glove with soil improvement, for if a check be given to the natural desires of the plant, *viz.*, to provide for a new generation, without supplying it with the materials necessary for continued growth, the shock may prove fatal. But it should

Improvement of Soil.
Conf. with paras. 58, 93-4, 108, 114-16, 128, 282-313.

never be forgotten that the cultivation of the tea plant, figuratively speaking, might be characterised as a forced procrastination in the fulfilment of a universal law of nature. And the simile which it is here desired to draw is but partially true. The lower portion of the stem may represent a seared old age, forced through pruning and cultivation, to continually renew its youth. But the presence of old wood in the stem, by retarding circulation and constantly forcing on the younger upper shoots the necessity to flower and fruit, must be injurious to the planter's aims and objects.

PRACTICAL LESSONS.

Old Wood.

68. Under the Chapters on Pruning and Drainage, an effort will be made to exemplify the chief peculiarities of the roots. It may here, however, be explained that absorption takes place chiefly in the minute hairs that surround the ultimate fibrils. Hairs are in many cases greatly elongated simple cells. They suck in the moisture of the soil, charged with food materials. This is transmitted from the young roots along the older roots to the stem and onward to the leaves. The activity of absorption depends, however, almost entirely on the demands of growth and is regulated by the leaves. Transpiration and assimilation are not physical phenomena. The mouths of the leaf are minute openings in the epidermis (stomata), mostly situate on the under-surface. These open, to allow of free transpiration, or close when a rest is desired, and thus directly control the roots. The strength of the ascending current of sap is accordingly dependent on the extent and activity of the young growing shoots and the number of fresh hungry leaves. Old mature leaves practically take no part in this action. They are thick, hard and dark-coloured, because the cells of which they are composed have become fully charged with food materials.

Roots.

Demands of Growth.

Breathing Mouths.

69. In the Chapter devoted to Plucking, an explanation will be offered as to the meaning of flushing. But in passing it may be said that the knife having secured for the planter, the effort, on the part of the plant, to produce new shoots (instead of maturing those already in existence, with the view to the production of seed), a vigour has been given to the roots which must either result in "bleeding" from the cut surfaces or in the production of more and still more shoots to take the place of those plucked off.

Flushing. *Conf. with paras. 206, 229.*

Flowering and Fruiting. *Conf. with para. 29.*

Bleeding.

70. From what has been said it, therefore, may now be fully understood that pruning for the production of leaf is, and must be, a very

Plant Life.

PRACTICAL LESSONS.

Uprooting and Replanting. *Conf. with paras. 77, 79, 280-1.*

hurtful and exhausting proceeding. It should, accordingly, be pursued with either of two objects in view :—

Preservation of Health.

(*a*) The death of the plant being accepted as a necessity, after a fixed number of years, the system of pruning should be that best calculated to secure the utmost return during the life of the plant.

(*b*) The object being to preserve the plant indefinitely, the system of pruning pursued should be that calculated to give the highest annual return, commensurate with the health of the plant.

Production and Area.

In connection with these two considerations the reader is referred to the remarks under Deterioration (*pp. 155-160*), more especially the concluding observations on the recent increased ratio of production to the expansion of the area of cultivation.

CHAPTER IV.

SEED GARDENS AND THE IMPROVEMENT OF SEED.

XIII.—Indigenous Seed.

INDIGENOUS SEEDS. *Conf. with paras. 29-30, 49.*

71. ***Localities.***—It may in all fairness be said that at present very nearly all that is stipulated for, in purchasing seed from a particular garden, is that a certain percentage shall germinate. The recommendation that the seed has been produced in an isolated spot, within a jungle or forest, where it is presumed to have been indigenous, may be said to vastly increase its value. The chief advantages claimed for such seed are, purity of *jat* and strength, due to the seed being the produce of semi-wild plants.

I made a point of personally visiting as many of the seed-gardens as I could, and may say that in none of those seen did the conditions exist that would satisfy me as a botanist, that the plants were, strictly speaking, indigenous. There was very little in fact to remove the suspicion that they might originally have been planted. One naturally had to face the very pertinent question,—How comes it that in the plains of Assam, the so-called indigenous tea, covers only small isolated patches of 5, 20, or at most 100 acres, while many miles of precisely similar jungle and forest extend around? I think I am correct, however, in saying that the seed-gardens of Assam very nearly correspond to the localities where the plant was found by Drs. Wallich, Griffith and McClelland (the Commissioners appointed by Government to enquire into the existence of tea in Assam) in 1835. It seems probable that the localities of the so-called wild tea within the valley, have not been materially increased in number since Dr. Griffith spoke of them as "patches of a very limited character." He mentions Kufu, Ningrew, Namsang, Tingri, Gabru, etc., etc. It is necessary, in fact, to leave the valley and to penetrate into the Naga Hills and Manipur before the tea plant can be said to form a feature of the prevailing vegetation over fairly extensive tracts of country.

Isolated Patches.

Then again the swampy jungles or damp dense forest tracts, in which most of these isolated plots of seed-tea occur, are about as dissimilar as it is possible to imagine, from the conditions that

Seed Gardens and the Improvement of Seed.

IMPROVEMENT of SEED.

Naga Hills and Manipur Teas.

Possible early Cultivation.

prevail, in what may be viewed as the forests of truly wild tea in the Naga Hills and Manipur. I do not think that it has been satisfactorily made out that there never was, on the fringe of high land that skirts the mountainous walls of Assam, a condition of native tea cultivation, such as exists at present in the Shan States, long anterior to the existence of the European industry. If this idea be allowed to gain credence, the observation repeatedly recorded by me, while examining seed-gardens, that in few indeed of these gardens could the *jat* of tea be pronounced uniform, would at once be accounted for. It does not by any means follow that the first China tea plant that reached the valley of Assam came to it, as the result of the enlightened action of Lord William Bentinck in his efforts to organize the modern tea industry. I have not infrequently seen unmistakable hybrid teas in some of these so-called indigenous seed-gardens, but even were these removed it could hardly be said that the remainder manifested throughout a constant type. "Assam indigenous" is, in my opinion, a very comprehensive term indeed, so that we should speak of bad *jat* Assam indigenous just as we freely admit the term bad hybrid.

Hybrid Bushes in Seed-Gardens.

Assam Indigenous-Variable Term.

Recognition of Forms.

Conf. with paras. 27 and 28.

72. ***Recognition of Different Forms.***—It may, in fact, be doubted, were the owners or managers of seed-gardens invited to pick ou the plots of land in a garden that had been planted with a certain percentage of their seed, whether they could make more than an occasional successful guess in that direction. In other words, I do not believe that any one of the famed seed-gardens could be said to produce more than seed of a certain locality, although it may be admitted that a distinct percentage of that seed has been proved to satisfaction to possess fairly constant properties. My contention is, however, that with a little more attention to the establishment, through selection and vigorous extermination of all departures from a required standard, it would be possible to very greatly improve the quality of the seed even in the existing seed-gardens. There should be no more any difficulty in the future to produce and maintain in each seed-garden a recognizable *jat* of tea, with ascertained properties and suitability to certain climates and soils, if not freedom from certain diseases, than there has been found to produce and maintain the famed pedigree wheats, or the prized races of potatoes, peas, cabbages, roses, fruits, etc.

Pedigree Seed.

Selection.

Conf. with para. 84.

Blight Proof Seed.

Conf. with paras. 53, 287-88.

Seed Gardens and the Improvement of Seed.

IMPROVEMENT of SEED.

The same attention has not been given to the subject of tea seed as has been expended on that of most other agricultural crops, and hence the apathy that prevails on the supply of seed. The manager of a garden on showing a plot of land under a certain famed stock, will often freely enough admit that it is by no means of one uniform *jat*. Inferior hybrids may be recognized in the field, but he will blame his own subordinates for not having rejected these in the nursery stage, instead of viewing them as possible indications of the condition of the seed-garden or of adulteration in supply. He may even uphold the opinion that seed from such and such a locality, whatever the *jat* may be botanically, has certain properties. In other words, he may maintain that the environment of the seed-garden is of equal, if not of greater, importance than the particular *jat* of tea grown in that garden.

Adulteration.

Selection.

73. ***Selection.***—It is needless to attempt to give here an essay on the principles usually followed in selecting and perfecting cultivated races of plants. Suffice it to say briefly that were I called upon to undertake such a task I should most certainly work back from the tea garden itself instead of forward from the so-called "jungle seed-garden." The tall unpruned plants in the seed-garden (or in fact all tea bushes left to grow at will) have lost most of the external peculiarities of form and colour of leaf, and habit of branching, by which they are recognizable the one from the other. It is accordingly a matter of considerable difficulty to identify the prized forms of the tea garden in the seed-producing state, since all become in the seed-garden very much alike. It follows that the various *jats* of tea found in the leaf-garden should be carefully studied and their various merits ascertained by comparative tests before any start is made with the seed-garden.

Working from the Tea Garden.

Individual Bushes Experimented with.

74. If by these means it were observed that one bush possessed certain properties of merit, such as, that it flushed exceptionally freely or early; that it enjoyed immunity or perhaps only suffered less severely from particular blights; or that it succeeded better on a peculiar soil (for which it was desired to have a special stock), than any of the other forms in the garden, I should single out that individual plant for experiment. So again if I found a bush that flowered and fruited freely in the stunted form of the tea garden, I should look upon that as a possible advantageous property that might be perpetuated with the view

IMPROVEMENT of SEED.

of producing from the Assam indigenous a plant that would in some respects resemble the China stock. I should have each bush that manifested special properties deemed worthy of investigation isolated, by an enclosure, so that it should not be plucked or otherwise interfered with. It could then be studied carefully with the view to ascertain whether the peculiarity it possessed was more or less fixed. It might then become necessary to cover it completely with a fine wire gauge frame so as to prevent cross fertilization on its reaching the flowering stage. After a sufficient supply of well-formed seed had been obtained from it, I should remove the enclosure and treat it like the other bushes, but have that individual plant numbered and recorded as the standard upon which improvement was to be effected and with which comparisons were in the future to be made of the results obtained.

Propagation by Cuttings.

Another method would be to produce by cuttings a large number of plants from some particular bush in order to see if its special property was preserved. Having previously selected and prepared a bit of good tea land in the jungles, say, a mile away from the garden, I should now sow the seed there or plant out the rooted cuttings. Doubtless many of the seedlings, after a year or two, would give indications that the seed had been hybridized in spite of every precaution. Every seedling or cutting that manifested the slightest departure from the arbitrarily selected standard I should have instantly removed, and after a time only some half a dozen of the best and purest retained. These I should allow to run to seed, but when the flowers began to form would pluck off a large number, and in order to secure fertilization within the specially selected individuals and to obviate the risk of external influence, would mechanically fertilize the flowers from which this second stage of seed was desired. After obtaining the required quantity I very possibly might next exterminate the plants in the seed-garden and trust to the new and less hybridized supply. Repeating the process of sowing I should again eliminate all the seedlings, say, when they were two or three years old, that manifested the slightest tendency to depart from the structural peculiarities that it was desired to develop.

Stock for new Seed-Garden.

This would take many years no doubt; but, by a process of careful selection, a definite type of plant could easily be developed and fixed. A supply of seed might then be obtained to plant out a fairly large seed-garden.

Objections to Improvement

75. ***Want of Continuity.***—As against all this I am reminded of

the want of continuity or continuance of interest in everything Indian. The scheme described would take years, and before it had advanced very far, those originally entrusted with the experiment would very possibly have disappeared from the scene of this very interesting scientific study. But if that be regarded as unanswerable, then the outcry against the spread of the diseases of the tea plant is irrational. If those who have the control of so many millions of pounds sterling cannot or will not follow the dictates of universal experience in all other branches of agricultural enterprise, there is nothing further to be said. But I cannot believe that the large, wealthy and influential companies that are concerned in the world's supply of tea, would admit that there existed any element of uncertainty in the matter. The executive may be changed, but any policy once inculcated need in no way suffer by such accidents.

IMPROVEMENT of SEED.

Uncertainty.

The suggestion might, moreover, be here made, for the consideration of the Tea Association, whether it would not be desirable to bring to India a professional seed-grower and to entrust to him the experiment of improving the quality of the tea seed, in a set of seed-gardens to be owned and supervised by the Association. But I am asked,— Could the owners of the present seed-gardens be expected to support such a scheme? Perhaps not; but if they are so short-sighted as to think there is no room for improvement, I should at once disregard their opposition. In all such questions the interests of the majority, not the minority, have to be considered. But let me add, I think it my duty to express my views on the necessity for reform irrespective of financial or even practical considerations. It is for those concerned with such matters to discover how far and in what way effect can be given to these recommendations, assuming that they commend themselves as desirable.

Professional Seed-grower.

76. ***Advantages of Uniformity of Stock.***—It is perhaps hardly necessary to reiterate the fact that gardens of mixed *jats* are far less productive than those in which greater care has been manifested in the selection of seed. It is also well known that gardens of fairly uniform and good *jat* are very nearly exempt from the ravages of mosquito, red-spider, etc. I have been taken over many such gardens and had convincing proof in others that it is in the inferior portions, with poor *jat* teas, where these and other pests first make their appearance, and from whence they spread to the better parts of

Advantages of Uniformity.

Conf. with paras. 79, 80, 201.

IMPROVEMENT of SEED.

Evils of Mixed Jats

the garden. To plant out a garden with some half a dozen *jats* of tea, one bush China, another Assam, and a third an inferior hybrid, or shall I put it two-thirds Assam and one-third inferior *jats* (dispersed through the better *jats*), is to provide the conditions necessary for blights to attack the entire garden simultaneously. It was a mistaken notion that to plant Assam and China bushes together secured a good blend of the properties of the two stocks. It has long since been proved to satisfaction that there are mechanical difficulties in collecting and manufacturing leaves of mixed size, age and thickness. Moreover, differences of *jat* involve a further difficulty in the season of flushing and time necessary to mature each successive flush. If plucked when the one *jat* is ready, the others may be too old or too young, and a loss that may be appalling is thereby sustained. If it be thought desirable to have early flushing as well as late flushing plants, let these be in separate plots where they can be plucked at their respective seasons. Blending cannot be successfully accomplished at the garden and should never be attempted since under the climatic conditions that prevail, during the manufacturing season, the sooner each day's produce is packed the better.

Flushing Season.

Blending.

Recognizable Forms.

77. ***Certain Forms of Tea found in most Gardens.***—Any person who may be disposed to doubt these very sweeping statements, regarding the wide diversity of quality and yield of the different bushes that compose the vast majority of the gardens in Assam, need only walk into the nearest plot of tea and compare bush by bush. He will find the greatest possible differences in the shape, colour, texture, degree of prominence of the veins and of the marginal serration of the leaves. If next he turns attention to the flushing power of two bushes of different *jats*, but of as near as possible equal size, he will find that one has only, say, 20 flushing shoots, while the other may have 100. Here, for example, is a bush with fine large, broad, thick and shining dark-coloured leaves, with coarse serration and with deep depressions between the widely arching veins. At a distance it looks not unlike a Cachar *jat* bush, but is larger and coarser built and spreads into stouter lateral branches than is customary with the Cachar. It was obtained, however, from the same seed-garden as the others and treated absolutely in the same manner as this other plant with smaller paler leaves and minute serration. The former may be seen to be liable to a peculiar blight. This may be

Laurel-leaved Tea.

Peculiar Disease. *Conf. with para. 831.*

IMPROVEMENT of SEED.

described. A constriction occurs at the base of the leaf, the sides are compressed upwards, the leaf turns over to one side under the wind, the now upturned under-surface becomes at first purple, then brown and dies; it is then attacked by a fungus. I have never seen that peculiar disease except on the Assam indigenous plant which I trust my description may bring to the mind's eye of the practical man. It may be asked,—Is that large clumsy plant anything like as productive as the smaller leaved, more erect bush growing alongside of it? The two forms of tea here indicated are to be found in nearly every garden in Assam.

Holly-leaved Tea.

The planter will now please turn round and look at this other bush, for behind him is a third form, a stunted plant with broad leaves that are deeply cut on the margin, until they almost look like those of the holly. These holly-like leaves will be seen to be abruptly terminated, instead of being gradually tapered. The newly formed wood has become prematurely brown and the plant is copiously branched and densely covered with ever-green leaves, but it flushes very indifferently. That is to say, the buds do not elongate quickly, the leaves rapidly become too thick and hard to be used as tea; the buds in fact sometimes look like small green roses, and the plant for all the good that it does might just as well be dug up.

Varying Quality.

Neither the laurel-leaved large bush nor the holly-leaved plant here indicated are profitable, compared with many other forms that might easily enough be substituted. Their dense dark green foliage give a vigorous look to the garden however, and thereby they escape the condemnation that they richly deserve. No treatment will ever succeed to bring bushes that are by nature non-productive into a state of efficiency. But I am told it will never pay to uproot even useless plants. That may be so (though I very much doubt it), but why plant useless bushes? A very short inspection of any tea garden will suffice to show most persons that there are different qualities of tea bushes both as to flavour of tea afforded and yield of leaf. If that be so, why should advantage not be taken of so ordinary an observation by developing the seed supply from selected stock.

Uprooting Tea. *Conf. with paras. 35, 70, 142, 164. 225, 276, 280-1.*

Hybrids.

78. ***Hybrids.***—The usual expression "hybrid" has been employed in some of the remarks above, though of course the tea "crosses" are not, botanically speaking, "hybrids" unless the China plant be regarded as a distinct species from the Assam, which it

Seed Gardens and the Improvement of Seed.

IMPROVEMENT of SEED.

Extermination of China Jats.

certainly is not. The term is, however, convenient and need not be objected to. While the popular cry of the present day is to exterminate all China tea and all hybrids and to substitute indigenous *jats*, I venture to think there may be a danger in carrying this idea too far. There are undoubtedly good as well as bad hybrids and for some soils and certain climatic conditions a good hydrid may be better than the purest and best Assam indigenous. The very worst argument against the hybrid teas is their greater liability to mosquito; their advantages are that they flush earlier and are less affected by deficient rainfall than the poorer *jats*.* As already pointed out, they are dangerous when intermixed with Assam indigenous, but under proper control might, in my opinion, be grown on special plots of land for which they have undoubted advantages.

Peculiarities of Hybrids.

Uniformity Vastly Improves Outturn.

79. The object I have at present in view, however, is to indicate the mixed character of the plants to be found in most gardens, in the hope of being able to convey the idea that a vast improvement in yield would result, were the gardens of the future planted with one form of tea only and that the one that had been ascertained of most value. With old gardens where uprooting and replanting are considered financially impossible I would say, see that every vacancy is filled up by the right *jat*, and it is possible much sooner than might be supposed at first sight a complete renovation may be effected. But to return to the subject of the races of the plant it may be said there is an infinitely more extensive series of hybrid, than of pure forms. Here, for example, is a large thick-leaved hybrid, with prominent veins, with the leaves exceptionally narrow for their length, pointed at both extremities, and with the sides of the leaf closed upwards so as to show the lighter undersurfaces. The whole attitude of the plant conveys the idea of being parched or of giving indications of suffering from heat and want of rain. Many planters point to these peculiarities as indicative of the approach of green-fly. I have seen the condition here mentioned scores of times without a trace of green-fly and that too from March to July. But I have never seen the peculiarities mentioned occur in any form of plant except the narrow, pointed, dark-green-leaved hybrid here described. Like many other forms of the tea plant this has very frequently a disease of its own which may indeed be the

Inferior Hybrid.

Coarse Plant with closed up Leaves.

Green-fly. *Conf. with paras. 302-10.*

* This latter fact I suspect may be due to shallow soil saturation. See chapter on Drainage.

cause of the convolute closing up of the leaves. Over the surfaces of the upturned portions will frequently be seen a multitude of brown or black spots that give the plant a very unsightly appearance. These spots are due to the growth of pustules imbedded within the tissue that contain a wart-forming mite which may possibly be peculiar to this form of plant.

IMPROVEMENT of SEED.

Wart-forming Mite.

Are hybrids of that character profitable? Count the number of flushing buds and you will see that whatever be the cause of the parched condition, the plant is "*banjhi*" (=barren) that is, its buds have been arrested in their growth and are unproductive. The particular form of plant here described is in fact infinitely more liable to become *banjhi* than is any other *jat* in the garden.

Banjhi Bushes. *Conf. with paras. 50, 206, 230.*

80. But there are other hybrids which in point of shape and size of leaf can only be definitely classified by counting the veins. They are sometimes called good hybrids, at other times bad *jats* of Assam. From the indigenous teas they may be recognized at a distance by their thicker texture, more parallel veination and darker colour of foliage and also by the important fact that they come into bearing at a much earlier date.

Veins of the Leaf. *Conf. with para. 27.*

But I forbear to mention further the long list of hybrids that might be described in this place—hybrids that differ from each other in shape of bush and size and texture of leaf until they gradually merge from the pure Assam into the pure China. An infinite series might be picked out in any one garden, many of the forms of which, if carefully studied, would each be found to have properties of its own.

81. ***Process of Hybridization.***—But before leaving the subject of these hybrids it may be as well to say that I did not come across a planter who had actually mechanically hybridized different forms and ascertained for himself the advantages or disadvantages of this method of dealing with the *jats* of tea. What is more surprising, I have a letter before me now from one planter who denies that the forms commonly called hybrids have been produced by crossing the Assam indigenous and the China. There can, in my opinion, be no room for doubt that they are crosses between the two races mentioned, but it is surprising that the production of these crosses should have been left to accident.

Hybridism.

Crosses not Hybrids.

It seems possible that the female element in the inferior hybrids may have been the China stock. But this could only

Experiment necessary.

IMPROVEMENT of SEED.

be determined by actual experiment. I desire pointedly to draw attention to the uncertainty that exists regarding the origin of the hybrids, in order to convey the idea that in crossing one Assam *jat* with another: Assam with Cachar; Assam with Sylhet; Assam with Manipur; Assam with Naga; Assam with Burma; or Assam with China, etc., etc., very different results may be obtained in each of these from two stock plants, *i.e.*, in the one case obtaining the seed from (*a*) Assam, in the other from (*b*) China. So again the strengthening effects of crossing the resultant with (*a*) or with (*b*) has not apparently been systematically tested. A very extensive series of such experiments might be tried, and who can say that he who follows these up may not produce a *jat* of tea infinitely superior to any stock at present in existence. Hybridism has hitherto been left to Nature; it has in fact been regarded as an unavoidable evil instead of being recognized as one of the possible means of solving the question of blights or of effecting improvements in the yield and quality of tea.

Mixed Stock.

Comparative Values.

Percentage of Quality in Seed.

82. ***Mixed Stock.***—The above remarks on the mixed nature of the stock in most gardens must be held as sufficient for the present purpose. Since it can be demonstrated that one plant is less productive than another, an importance is at once given to a more careful selection of seed, that should commend itself to all persons interested in tea cultivation. How the many difficulties that beset the adoption of measures of reform are to be overcome must be left for practical men to determine. It seems likely, however, that were a stipulation made, in seed transactions, as to percentage of quality as well as of germination, the companies who do a business in supplying seed would soon find it to their interest to free their seed-gardens of all doubtful palnts. So far as I understand the contracts simply stipulate for seed of a particular seed-garden (such as Bazaloni, Tingri, Namsang, etc., etc.), but make no provision for uniformity of *jat*. It is apparently accepted that seed from a certain seed garden is of uniform quality.

XIV.—Seed-Gardens.

Garden-Seeds.

83. ***Seed-Gardens.***—I cannot close these remarks on the desirability of effecting improvements in seed without repeating the conviction that there is involved in the craving for seed from the jungles,

an error that, in my opinion, very largely underlies present evil. The seed-gardens are practically jungles that are cultivated very occasionally and indeed are situate, as a rule, in localities of such a nature that they can be visited at certain seasons only. For example the manager of one of the special seed-gardens informed me he would lend me an elephant, to enable me to try to visit the seed-garden, but would not undertake to accompany me nor give me any guarantee that I might be able to reach the garden. This was in June when the garden in question was supposed to be cut off from all communication by inundation, and for many months to come would be so. The plants are thus to a large extent neglected. They are not infrequently badly blighted and may thus be admitted are widely different from the plant as met with in the true wild habitats of the species, dealt with under paragraphs 11 and 27. I have seen more fungal blights in one or two seed-gardens than anywhere else, and some of these may possibly be found to be hereditary. On one occasion my attention was drawn to the fact that a fungal disease (Brown Blight) seen on the leaf often attacks the superficial structure of the fruit and could be even recognized on the contained seed. Nearly every tree in most seed-gardens bears, as a rule, a **Loranthus** that is sapping its life and lessening its power to produce healthy seed. These parasites are doubtless systematically removed, but in the intervals of the visits paid to the seed-gardens, the trees become again attacked.

IMPROVEMENT of SEED.

Cut off from all Communication.

Brown Blight. *Conf. with para. 828.*

Loranthus. *Conf. with para. 708.*

84. In my opinion, therefore, it would be preferable to the present system, were every large company to open out a seed-garden of its own, in some suitable situation and within manageable distance of head-quarters. The first step in that direction should be the selection of the stock, and in this the very greatest care should be manifested. Advantage in every direction might be expected to follow an almost hypercritical study of the seedlings intended for the future seed-garden.

Selection of Stock. *Conf. with paras. 72-74.*

85. ***Cultivation Necessary.***—The plants should be regularly and carefully cultivated, in fact to a greater extent than in the leaf-garden. It is hardly necessary to repeat that it is an erroneous assumption that seed from the neglected jungle, ordinarily called a seed-garden, can be superior to that obtainable scientifically. What such seed may be supposed to gain in strength, by production in a state of nature, is infinitely more than counteracted by the evils of the system. To argue that the wild seed of any plant could be superior

Cultivation.

Cultivated Seed Superior to Wild.

Races of Stock.

to cultivated is to affirm that agriculture has not and cannot effect improvements in any direction, however much these may be desired by men. That wheat, oats, sheep, goats, etc., etc., existed in nature from all time as they do now, and that were we able to discover the original source from which the prized races of plants and animals had been evolved, it would be preferable to breed from the wild rather than the specially developed stock. With ideas of this kind currently held it would almost seem that the conception of possible improvement of stock was an unheard of doctrine—a mere theoretical speculation.

Seed-Garden Sites.

86. ***Selection of Site for Seed-Garden.***—To cause a healthy-bush to produce seed, its treatment must be entirely different from that pursued when the object is a perennial flushing of leaf. The soil selected should approximate as near as possible to that already mentioned as characteristic of the tracts of country in which the plant is truly indigenous. Low-lying, swampy, black, heavy soils, with much decomposing organic matter, should be avoided. A soil of red-clay loam, rich in lime and magnesia, should be specially selected and common salt added as a manure, should the soil be deficient in chlorides.

Habitat of Wild Tea. Conf. with para. 11.

Sa Tree. Conf. with paras. 11, 110, 297, 302-3, 311, 573.

In its truly wild state the tea never occurs in dense forest but rather in association with open mixed scrubby vegetation, and hence the seed-garden might with advantage be interplanted with clumps of some of the smaller bamboos and with *Sa* trees (Albizzia stipulata).

Pruning for Seed.

87. The pruning that should be annually given to the bushes should be the removal periodically of all branches that had already borne a sufficient amount of fruit or that were giving indications of becoming exhausted. The primary aim should be to produce a healthy well-formed bush, with as little superfluous wood as possible. It is a matter of some practical importance to prevent the bushes from running into unmanageably large sizes, since in that state they incur the risk of being broken during the rough handling they are often subjected to, in the collection of seed. That object would very possibly be attained by the systematic removal of one or more branches every three or four years. In fact the lopping off or thinning out of a certain percentage of overgrown boughs would do less harm to seed-production, where quality of seed was aimed at, than

Size of Bushes.

Collection of Seed.

IMPROVEMENT of SEED.

Root-pruning.

a more extensive system of light pruning. The pruning that should be pursued may briefly be said to be similar to orchard cultivation generally. But root-pruning should be systematically followed and that too every now and again. Deep cultivation is also essential, and opportunity should then be taken to cut a certain percentage of the roots. The deep hoeing and root-pruning should, as a rule, be accomplished not later than January and should only be undertaken when the soil is comparatively speaking dry. Deep hoeing in damp clay soils is distinctly injurious though sub-soil drainage with pipes placed at a safe distance from the roots would vastly improve the majority of seed-gardens.

Seeding.

88. ***Seeding.***—In Assam gardens the tea plant very nearly flowers throughout the year, but in the seed-garden it matures its fruits in October and November. Mr. Culbard, of Soongal, Kangra, informs me that in the tea gardens of Kangra, it ripens fruit from the 15th October to 15th November. In Assam ripe fruit may be seen occasionally at any season and this eratic seeding is distinctly objectionable. I picked ripe fruits from a seed garden, visited by me in the latter end of June. By careful selection there should be little difficulty in producing a stock that would fruit more uniformly, if not also at a more favourable season than at present.

Danger of Hybridization.

The danger of hybridization from the China stock, in the neighbouring gardens, is rapidly being removed, owing to the greater popularity of the Assam *jats* and the disappearance of the China. But with a few miles of jungle between the seed-garden and the tea there never was any great risk of cross-fertilization. The chief danger lay in the fact of mixed qualities existing in the seed-garden itself.

Seed Produced in the Ordinary Leaf Garden.

89. ***Seed-Production Dispersed through Tea Gardens.***—The habit of allowing, over certain portions of a tea garden, a selected number of bush to grow up for seed-production is, in my opinion distinctly reprehensible, as compared with the opening out of special seed-gardens. Even were all plants in the gardens of one uniform *jat*, so that the risk of crossing might be regarded as entirely removed, the seed-bearing plants, under these conditions, cannot obtain, without injury to the leaf-bearing stock, the necessary treatment. In all the gardens where I have seen this system pursued, the plants are simply exaggerated leaf-bearing bushes and possess none of the

Cannot be Properly Treated.

Conf. with paras. 41, 72, 76, 79, 261.

IMPROVEMENT of SEED.

peculiarities that are essential to the production of a limited quantity of high class seed. Personally I should prefer the seed from the jungle gardens to that of leaf-bearing bushes that had been selected for seed-production.

Exchange of Seed.

90. ***Exchanges.***—But there is one point that must still be mentioned on the subject of seed-production. It is the all but universal experience in agriculture that seed had better not be raised in the locality where it is to be sown. An advantage is universally admitted as secured by an exchange of seed. But were all the larger companies to accept, as an obligation laid on them, the duty of opening out seed-gardens and scientifically studying the best methods of producing the most approved *jats* of tea, exchanges might easily and profitably be effected. Indeed the extent of property held by many of the larger companies is such that with two or three small seed-gardens in different corners of their estates they need have no fear in using their own seed.

Improvement in Yield.

91. ***Conclusion.***—It is known that certain blights show a decided preference for certain races of the tea plant. Where such blights prevail to a ruinous extent selection of stock might amount to a successful remedial measure. The subject of seed-production should, therefore, not only commend itself to every person interested in tea, because of the high prices demanded for good seed, but because of the radical reforms and economies that would soon be effected were all future gardens, extensions, and replantations, made with carefully selected and approved stock. An undoubted increase of yield, with a corresponding lessened cost would take place and blights become of very much lessened consequence.

CHANGE in RELATION to DISEASE.

CHAPTER V.

HOEING AND WEEDING.

XV.—Change in Relation to Disease.

92. The foregoing remarks have set forth some of the reasons that are believed to justify the opinion that, by the systems of cultivation pursued in Assam, the physiological and even the structural peculiarities of the tea plant have been, and are being, constantly distributed. The not unnatural result must be the gradual production of a cultivated stock that is not only diversified, but which collectively is gradually departing from the structural characteristics and chemical properties of the original wild plant. The changes that have already been effected may be said to be on precisely similar lines to those that in China ultimately produced the form known to the Indian planter as the "China bush."

Production of New Conditions. *Conf. with paras. 26, 30, 45, 51, 106, 166, 186, 197, 315, 318, 320.*

China Bush.

It has in consequence been contended that thereby the plant has been, and is being, brought into a condition of predisposition to disease.

Predisposition to Disease. *Conf. with paras. 30, 32, 47, 226, 282.*

In a series of chapters below some of the chief pests and blights, that have already invaded the tea plant, will be dealt with; but it would appear desirable that an attempt should be made to discuss here the problems of cultivation that have been assumed as connected with the appearance and distribution of disease. In approaching this part of my subject I am conscious that I very possibly may be regarded as advancing theoretical opinions in opposition to the accumulated experience of half a century of practical tea-planting. For my shortcomings I crave indulgence, but I may say that the time allowed me precludes my touching on more than a few out of the many aspects of tea cultivation that seem to me to deserve more careful study than has hitherto been bestowed on them.

XVI.—Objects of Tillage.

93. Tillage of the soil may be said to be undertaken with the two-fold object, *viz.*, to open it up, in order that water may penetrate freely, and to turn up or expose again and again fresh portions of it to the direct action of both heat and air, in order that disintegration may take place. By these means the soil is mechanically pulverised

Objects of Tillage. *Conf. with paras. 54, 116, 136.*

Hoeing and Weeding.

OBJECTS of TILLAGE.

Chemical and Physical Changes. *Conf. with para. 116.*

Rain-water.

Fertility.

Nitrogen Giving Organisms.

and at the same time undergoes certain very necessary chemical and physical changes that are essential before it can become available as plant food. Rain-water may be said to be nature's chief manurial agent. It holds in solution a large quantity of air which, as we know, consists of oxygen, nitrogen, carbonic acid, nitric acid and ammonia. Rain-water, moreover, has been warmed both in passing through the air and by its contact with the warm surface soil. Heat and oxygen bring about important decompositions in the organic ingredients of the soil; the acids enter into union with its insoluble matter and render much of it soluble; while the nitrogen of the air feeds the organisms of the soil, that are indispensable to the life of the higher plants. It is thus self-evident that if the soil be not fully and freely permeated by rain-water, it cannot be productive. Further, the more frequently and completely that the surface soil is broken up and exposed to the sun, air and water, the greater will be the disintegration of its insoluble mineral ingredients and the higher its fertility.

Extent of Tillage for the Tea Plant. *Conf. with paras. 54, 155, 283.*

94. These then are the reasons that justify the hoeing, ploughing and draining of the soil. In a letter dating back some 25 years, a planter who signed himself "Dash" remarked :—"If any one could inform us, planters, how the stirring up of the soil acts on the growth of the plants, we might take an intelligent interest in the cultivation of the ground." The answer is of course that cultivation, by the greater diffusion of air and water, enhances the volume and brings into the condition capable of being absorbed, the plant food-materials of the soil. But the further questions, by the same writer, show that he was by no means ignorant of the necessity for cultivation, but rather wished to ellucidate the nature and extent of the operations necessary for the tea plant. He accordingly proceeds to ask "whether it is better to have a well-stirred up garden, with a slight coating of grass, *without wash*, as is the case when the garden is forked over, than to have a clean hoed garden, *baked by an Indian sun, after the surface has been smoothed by the rain and wash?* And does deep cultivation, say 9 inches, for the sake of allowing the moisture to descend, compensate for disturbing the roots when the bushes are growing? If the garden is lightly forked over in the rains, would it be necessary to turn up the under-soil in the cold weather?"

Extent of Weeding Necessary.

Surface Wash. *Conf. with paras. 99, 116, 124, 127, 153, 157, 216, 271.*

95. These pertinent questions roused the most superficial contro-

OBJECTS of TILLAGE.

versy in the technical literature of the day and practically remain unanswered. The greatest possible difference of opinion still prevails all over Assam, for example, as to the number and depth of the hoeings that are necessary. The hoe *versus* the fork is still a theme hotly contested by men of long experience. The utility *versus* danger of weeds, can hardly be regarded as a subject of debate at the present day. The opinion is all but universal that the freer a garden is of weeds the better. And yet there would appear to me to be no doubt that weeds of a particular class, by growing on the soil for short periods, would not only aid, as "Dash" suggests, in checking ruinous surface wash, but help in establishing the balance of the soil, so seriously disturbed by the cultivation of extensive tracts of country with a perennial bushy crop. I am fully aware that weeds with long powerful roots and stems which rise up above the height of the tea, would both injure the roots and suffocate the leaves. There must be nothing that would either interfere with the activity of the roots or retard the vigorous growth of the shoots, but can it be proved that succulent herbaceous weeds that do not exceed a foot in height, by being left on the soil for a couple of months or so injure the tea? Would it not be safer to assume that by their taking the carbon from the air and building that up with the nitrogen and inorganic materials of the soil, weeds of the kind indicated assist in the improvement of the soil? When hoed into the surface, in a moist green state, is it not safe to affirm that they are at once decomposed and act as green manure by giving back to the tea, in a prepared condition, the substances temporarily abstracted from the soil.

Value of Weeds. *Conf. with paras. 99, 107-9, 143, 267, 291-313.*

Balance of the Soil.

Ferns, etc. *Conf. with paras. 23, 800.*

Value of Herbaceous Weeds. *Conf. with paras. 99, 109-11, 294.*

Green Manuring.

96. There is, however, a limit to the extent that even hoeing is beneficial. Every time the soil is turned up and pulverised it is exposed to the action of the atmosphere. It is dried, made porous, and oxidised. If a soil be already too porous, hoeing beyond a certain limit may become positively hurtful. Porous soils have usually a very low percentage of organic matter, as already explained, namely, that being porous, their organic materials have been rapidly oxidised and used up. For these reasons then rules for the hoeing of all gardens on a common plan cannot and should not be laid down, no more than that pruning can be made on the height principle, regardless of individual requirements.

Over-Cultivation

Sandy Soils and Deficiency of Organic Matter. *Conf. with paras. 113, 157, 285, 291, 313.*

Hoeing and Weeding.

OPINIONS of AUTHORS.

It may help to bring out more clearly the opinions that prevail on the subject of hoeing if I furnish a brief abstract from the literature of this subject.

XVII.—Opinions of Authors in Hoeing of Tea Estate.

97. Mr. H. A. Shipp *(Prize Essay on Cultivation and Manufacture of Tea in Cachar: Journal, Agri.-Horti. Soc., Ind., Vol. XIV, Published, 1866)* says:—"Hoeing should be constantly (say once in every two months) performed to a depth of at least 18 inches, and, on each subsequent occasion, to transplanting (prior to which two hoeings have been directed) the earth should be turned over in large clods with the roots of the weeds exposed, as they will thus die more rapidly and return to the soil, by being left on it, all the nourishment they have extracted from it." He further adds, "It is advisable to loosen the soil occasionally round the roots of the tea plants so as to give a free admission of air and moisture, and for this purpose the hand-hoe is best adapted, as in the use of the regular hoe, great danger is incurred of cutting the lateral roots of the young tea-trees."

Six Deep (18 Inches) Hoeings a Year.

98. Mr. W. C. Muller *(A few Observations on the Treatment of the Tea Plant in Darjeeling: Journ. Agri.-Horti. Soc., Ind., Vol. XIV., 1866)*—remarks that "The invariable practice on most plantations is to keep them as clean as possible by frequent deep hoeing throughout the year. I have four objections to this system:—

Objections to Frequent Deep Hoeings.

1st.—The very great loss of soil by wash during the rains.

2nd.—The injury done with the hoe to the roots of the seedlings.

3rd.—The collar of the plant invariably gets covered.

4th.—The total deprivation of shade."

"During the fourth year the seedlings will have become a tree. You ought, if practicable, to give your plantation a deep hoeing, that is to say 8 inches, in September, just before the close of the rains, on every other occasion, when necessary, hoe lightly. If you wish to obtain a good supply of leaf, never allow the jungle to get more than 6 inches high during the rains; to ensure this you will find it necessary to give a light hoeing once a month."

Value of Weeds: should not exceed 6 Inches.

Conf. with paras. 109-111, 294.

99. Mr. Muller wrote of Darjeeling and his remarks may be regarded as more especially applicable to gardens situate on hilly slopes. I hope, however, in a further chapter, to show that even on

the flat expanses of tea land in Assam surface wash is a frequent and dangerous phenomenon. **OPINIONS of AUTHORS.**

To **Mr. Muller's** four arguments in favour of a moderate coating of weeds being beneficial a fifth might be added, namely, that they protect the soil from the excessive evaporation of the hot months of April, May and part of June.

100. In passing I may invite attention to the first writer who pointedly drew attention to the fact that *ulu* grass **(Imperata arundinacea)** was one of the weeds that were distinctly hurtful to tea, *namely*, the late **Mr. J. W. Masters.** In a letter dated 22nd November 1859 (*Selections from the Records, Government of Bengal, No. XXXVII., pp. 47-48*) he gives many interesting particulars regarding this grass, and his remarks contrast somewhat strikingly with the position of that enemy of tea cultivation at the present day. Constant tillage may be said to have eradicated the grass, to a considerable extent, from actual tea land.

Ulu Grass. *Conf. with paras. 108, 110, 329.*

101. **Colonel Money** (*Prize Essay on the Cultivation and Manufacture of Tea; first Ed., 1870; fourth, 1883*), tells us that tea "will only pay with high cultivation, for high cultivation consists in frequent digging, to keep the soil open and get rid of weeds." In his special chapter on *The Cultivation of made Gardens* he says, "To conclude shortly, for 'hoeing and weeding' I recommend as follows :—

"Dig the whole garden thrice in the year, *viz.*, spring, rains, and autumn. Bury all weeds as you dig, in trenches between the lines. In the intervals use the Dutch hoe as often as weeds appear. Cultivate the plants by digging round them once a month if possible."

Three Main Hoeings Recommended.

Light Hoeings once a Month.

"Do all this and you will find your garden is kept clean and well cultivated, at far less cost than you incurred for cultivation when it was choked with weeds for months together, while your yield will be at the same time much increased."

102. **Mr. J. F. W. Watson** (*Prize Essay, Journ., Agri.-Horti. Soc., India, Vol. III., Pt. II., 1872*), gives a very long and somewhat tedious chapter on this subject, although in many directions it is highly instructive, more especially in the passages that deal with the eradication of injurious deep-rooted grasses. He concludes as follows :—"To sum up the whole of these remarks to a practical conclusion, I would say that all lands under tea cultivation should be well deep hoed in the cold season; *secondly*, that wherever *dhaub*, *ulu* or other

One Deep Hoeing a Year.

Hoeing and Weeding.

OPINIONS of AUTHORS.

Four or Five Light Hoeings.

such grasses infest a garden, no effort should be spared to thoroughly eradicate them, if for no other reason than that they are directly injurious to the roots of the bushes; *thirdly*, that from March to the 1st of November, the land should be light hoed at periods which should not be of greater frequency than once every six weeks, which interval, however, should not be much prolongated."

Mr. Watson, though originally an Assam planter, wrote mainly of the tea gardens of the North-Western Provinces.

Systematic Weeding.

103. Mr. T. G. Stoker (*Notes on the Management of the Tea Plant in Cachar, 1874*), says of gardens in full bearing, "The great desideratum is that the lands shall be kept free from weeds and other rank growth which tend to keep the ground in a continually cold unhealthy state." "To hand-weed and hoe alternately I consider a good plan and during the rains this should be done as frequently as can be afforded." "During June, July and August the garden should, if possible, be kept scrupulously clean, and the surface crust occasionally broken with the hoe, so that the plants may be in an active warm state and thus suffer less from excessive rain."

Temperature of Soil.

104. The chapter below on Drainage will, I trust, show that the line of reasoning pursued by Mr. Stoker as to the soil being cold when covered by weeds is a little obscure and not in accordance with the usual experience. If properly drained, land can never be said to be injured by rain short of actual inundation. But Mr. Stoker returns to the subject and is certainly correct when he says, "Deep hoeing during the rains is injurious." The true reason for this is not, however, that given by Mr. Stoker, but will be found in an article that appeared in the *Tea Cyclopædia* (reprinted from the *English Cyclopædia*), namely, that clay soils if interfered with when saturated with water are very apt to cake (the process known as puddling) when they become impervious to both water and air. As the best tea lands are clayey loams, it may be accepted that the risk of caking is very great. Although not quite in the sequence of this brief abstract from writers, on tea cultivation, it may be said that Mr. Bamber's remarks on the injury done by hoeing saturated clayey soils are both instructive and accurate. He writes of heavy clayey soils, "These soils should, if possible, never be hoed during heavy rain, or when completely saturated with moisture, as hoeing at such times is certain to make them more consolidated and compact than ever, rendering

Deep Hoeing in the Rains Injurious.

Conf. with para. 116.

future hoeings more laborious and expensive. If the hoeing is done when the surface soil has become a little dry, it will be found that the soil will not become as adhesive as before, and if this method is continually practised, it will rapidly become more open and friable."

OPINIONS of AUTHORS.

One Deep and Three Light Hoeings.

105. **Notes on Tea in Darjeeling** is the title of a little book that may be here placed under contribution:—"One deep hoeing and two or three light hoeings are all that are required by a hill garden. The garden ought to be hoed deeply in November, and as big clods as possible turned up and left unbroken, thus letting as much light and air into the soil as possible. No more hoeing should be done until May." "Many planters hoe deeply, during the cold weather and go over the land in March, breaking up all clods, the real reason in many cases, why this is done, is that the agents have ordered the managers to hoe the garden a fixed amount of times, and this is an easy way out of it."

Hoeings Regulated by Labour, not Requirements.

106. By far the most valuable account of tillage of land, in adaptation to tea cultivation, is that by **Mr. M. Kelway Bamber** (*Chemistry and Agriculture of Tea, 1893*). "Cultivation of tea soils," he says, "at the present time is confined almost entirely to hand-weeding, forking, or hoeing, chiefly the latter, and the amount and kind of such cultivation is regulated more by the amount of labour available on the garden, than by the requirements of the different classes of soil. It is a well-known fact in agricultural practice, that heavy and light soils must have very different treatment, if successful results are to be obtained, and the same thing holds good in respect of tea soils, though, as a rule, it seems to be lost sight of. It must be remembered that it is as easy to over-cultivate some soils, as to under-cultivate others, resulting in both cases in detriment to the bushes."

Over and Under-Cultivation.

XVIII.—Advantages and Disadvantages of Weeds.

WEEDS. *Conf. with paras 98, 99, 143, 267, 291-313.*

By Cultivation is meant Hoeing.

107. It would be unnecessary for me to quote any further from **Mr. Bamber's** most admirable chapter on Cultivation. His book is in the hands of most planters, and this chapter deserves very careful consideration. I not only concur most heartily in the opinion advanced in the last sentence, but were it desirable could mention several gardens, with light friable soils, where I am satisfied injury is being done by over-hoeing. Indeed I am strongly of opinion that in the majority of gardens the error tends to lie on the side of over,

WEEDS.

plant, or which exist in a condition unsuitable for it, are accumulating, until the time might be supposed as rapidly approaching, when such accumulations may become positively hurtful. No rotation of crops is possible with a perennial, such as tea, and the only way, as it seems to me, to meet this difficulty is to encourage the growth of especially selected weeds for a certain number of months a year. These would undoubtedly attack the very ingredients of the soil tea does not use, while on being hoed into the soil they would furnish a greatly needed additional supply of organic matter which the tea urgently requires. If, therefore, a certain proportion of the weeds encouraged and even sown on tea land, belonged to the family of the clover (leguminous plants), these would greatly facilitate the much-needed supply of nitrogen to the soil. I shall return to this subject in connection with Drainage and the Manuring of tea lands and need only add, therefore, that I am in favour of some scheme being designed by which specially selected weeds are allowed to occupy the soil for a certain number of months a year.

Nitrogen Giving Weeds. *Conf. with paras. 62, 93, 116, 165, 285, 294, 296-313.*

Hoeing and Nothing but Hoeing.

The doctrine that cultivation of tea means hoeing, and nothing else but hoeing, I most distinctly demur to accept. Moreover, I feel more than convinced that the unhealthy state of the tea bushes in many gardens should, to some extent at least, be attributed to excessive hoeing.

Diary Notes on Hoeing and Weeding.

110. The following passages on this subject may be given from my Diary:—

At a garden visited on 24th April, some half a dozen planters met together and a discussion ensued on many important practical questions. The possibility of over-cultivation came up. One gentleman said he knew cases where increased coolie labour and more hoeing had vastly improved the yield. He held that *Sa* trees had not been shown to increase the yield though he admitted that an estate, where they had been largely grown, was one of the finest in the district, and its last year's profit a very handsome one.

Advantage of *Sa* Trees.

He thought that, if every bush could be pruned on its own merits (*p. 102*), it might be of advantage; but that by pruning on a fixed system bad plants were killed off and the garden brought to a uniform state in which a definite system for all practical purposes became possible.

Standard Pruning Possible.

If not given at least three deep hoeings a year, he believed, the jungle would kill the tea. He remarked that the garden roads in August and September had often grass 3 feet high. He did not believe that *ulu* grass was disappearing from Assam, or that any change in the grass lands was taking place other than what was being effected by better cultivation. Another gentleman, on the other hand, said that, during his 20 years' experience of Assam, he was convinced a great change had taken place. In support of this he remarked that it was well-known fact that mid-season was much later in most gardens than it was formerly.

***Ulu* Grass.**

Mid-Season.

Hoeing and Weeding.

WEEDS.

Over-Cultivation Admitted.

Most of the planters present were, however, of opinion that over-cultivation was distinctly taking place. That surface cutting of weeds did not effect anything more than to temporarily cut them back. That the system of frequent hoeing did not effect any real disintegration of the soil. They agreed, however, with the suggestion, that a better class of weeds carefully selected and encouraged to grow instead of being hoed out, would do good.

Mati Kalai as Nitrogen Crop. Phaseolus aconitifolius.

There is no *Sa* trees in .... garden and the superintendent does not think there ever had been any. The soil is very dry and contains only about 0·04 nitrogen, expressed as Ammonia. He, therefore, agreed that *Sa* might do good, but he would prefer to try *mati kalai* or some herbaceous legume rather than a tree, the shade of which was distinctly objectionable.

Hoeing New Land before Transplanting.

At Patalipam, North Lakhimpur, I had some conversation with Mr. J. Lindsay Alexander on the subject of weeding :—

"I never hoe the ground before planting. I simply clear the jungle and by *kurpe*, take out the surface weeds for a space 15 inches in diameter, in order to clear a place for the seedlings. And until the period of hoeing I see that the weeds are kept down on these small seedling clearances. When the plants are 18 inches high, the ground is thoroughly hoed. This system I have pursued owing to the fact that, in my opinion, the jungle grows less if not hoed. It is also my experience that indigenous growth makes no special effort for existence if left alone."

Artificial and Foreign Weeds.

111. ***Foreign Weeds.***—There is certainly much truth in Mr. Alexander's observation of excessive hoeing giving facilities for the growth of a uniform instead of a mixed crop of weeds. A broken loose and empty soil is more likely to harbour seed brought by wind and other agencies than a soil with its natural herbage. Foreign weeds are a greater danger to agriculture than indigenous growth, and an empty soil is sure to become clothed with some exotic, or with one weed covering the entire area instead of the mixed herbage characteristic of all natural growths. To the botanist visiting Assam, nothing would perhaps strike him with greater force than the artificial character of the weeds found on tea gardens. There is a painful uniformity, from one end of the province to the other, and a marked dissimilarity with the adjacent vegetation. In Assam there are remarkably few leguminous herbaceous plants. That family is mainly trees or extensive climbers. In tea clearances, therefore, the entire series of leguminous plants may practically be said to be removed. The prevailing type of tea weeds is composite plants, chiefly a purple-flowered Blumea and one or two exotic and pernicious weeds now common to most Indian cultivated areas. Where the cultivation is annual and a rotation of crops takes place, exotic weeds may be said to be infinitely less hurtful than with a perennial crop such as tea : hence the necessity for a more natural herbage.

Artificial Nature of Weeds on Tea Estates.

DRAINAGE.

CHAPTER VI.

DRAINAGE OF TEA GARDENS.

Objects of Drainage.

112. It has been said that "to drain land is to rid it of its superfluous moisture." That is the most generally accepted idea, but the objects aimed at are to increase the depth and improve the condition of the arable soil. The drainage of agricultural land thus differs essentially from that of the streets of a town. The removal of surplus water is undertaken with a definite purpose in view, the fulfilment of which determines the position and number of the drains that may be necessary. To understand, therefore, the principle involved by the conception of superfluous moisture in agriculture, it becomes necessary to devote, *first*, some attention to the study of water and its influences on the soil, and, *second*, to consider the functions it performs in the economy of plant life.

XIX.—Water and its Relation to the Soil.

Solvent of Food Materials.

113. In the first place, then, water may be said to be the solvent by means of which the food materials of the soil are taken up by the roots. But in addition to water passing into and being diffused through the soil, by virtue of this dissolving power, it is very much more largely drawn down by another physical law, namely, the affinity for water which the various ingredients of the soil possess. All soils, it may be said, have the power to absorb and retain water apart from the temporary disappearance of certain of their ingredients in the state of solution. Soils may be regarded as built up of mineral particles of varying sizes and properties with interspaces occupied by water and air. No soil, however dry it may appear, is totally devoid of water and air. A soil is saturated when it contains the maximum quantity of water and air that its interspaces are capable of holding naturally. The water is then said to exist as moisture. The absorbing property of a soil is, therefore, determined by the quantity of water and air that it is capable of holding in the condition of moisture. And this again is regulated by the chemical and mechanical conditions of its mineral particles. Water is diffused through the soil by what is called "capillary attraction," the interspaces act like tubes within which the water is rapidly distributed. The shape and size of these interspaces is

Movement of Water in the Soil.

Soils. *Conf. with paras. 282-313.*

Saturated Soils.

Soil Moisture.

Capillary Attraction. *Conf. with paras. 63, 120.*

Drainage of Tea Gardens.

WATER in RELATION to SOIL.

Soil Affinity for Water.

Sandy Soils. *Conf. with paras. 96, 157, 285, 301.*

Parching of Soils.

Evaporation and Absorption.

Water-logged Soils.

entirely dependent on the mechanical condition of the mineral particles. But the chemical and physical properties of soil ingredients aid materially in this absorption and distribution of moisture. Sugar will be dissolved if placed in contact with water, but castor oil is neither dissolved nor will it mechanically mix with water—it has no affinity for it. Clayey soils manifest a strong affinity and sandy or gritty soils a very weak affinity for water. Dry clay will absorb from the atmosphere as much as 5 per cent. of moisture in 24 hours, while sand, unless in a very fine state of division, will hardly absorb any. Water is thus attracted to, retained by, and distributed within the soil, until the maximum absorbing point has been attained. With clayey soils this is much higher and therefore reached considerably later than with sandy soils. Soils that soon become saturated are those that get the soonest parched. In soils with a due portion of clay the moisture rises up gradually from below to replace surface evaporation, and such soils, therefore, dry slowly, because of the strong affinity for water possessed by clay. So again clayey soils absorb the night dews, and thus to a certain extent compensate for the daily surface evaporation by night absorption. During heavy rains an excess over saturation still passes through the soil to the underground channels of transmission by simple gravitation, but even still very largely in consequence of the peculiar affinity of clay for water. The excess does not at all events tend so readily to flow on the surface of clayey loams as is the case with saturated sandy soils, the ingredients of which possess little or no affinity for water. From these considerations, therefore, it may be said a soil is water-logged when it retains a surplus proportion of moisture over saturation, the surplus existing not as moisture but as actual water.

Improvement of Soil Conditions. *Conf. with paras. 58, 67, 93-4, 128, 282-313.*

Culturable Depth restricted by Water.

114. ***Improvement of the Soil.***—Having thus briefly indicated what is meant by superfluous water, it may be as well to similarly exemplify the principles involved in the improvement of the physical and chemical conditions of the soil through drainage. When superfluous water exists in a soil for any length of time, terrestrial plants are drowned. The effect on the tea plant of a water-logged soil will be at once apparent when it is recollected that, in its wild habitat, it is a native of mountain slopes. By way of illustration, therefore, if water accumulates in a tea garden, at a certain depth below the surface, its presence must restrict the extent of culturable soil, for the roots of

Drainage of Tea Gardens.

WATER in RELATION to SOIL.

the tea plant will certainly not live in water. It follows that an agency that will carry the water to a lower depth than it might flow naturally, will increase by that extent the culturable depth of the soil. So again should the removal of surplus water from a soil be left to evaporation, many very injurious influences are brought to bear on the crop and on the soil. It is a well-known fact that evaporation lowers the temperature. Water, before it can be expanded into the condition of vapour, must obtain a large amount of heat. A badly drained soil that contains an excess of water has its temperature lowered through the utilization of the earth's heat and the absorption of the sun's rays in the accomplishment of evaporation. As the Spring advances and the sun's rays become hotter and hotter, evaporation increases and the soil becomes colder and colder. A fall in soil temperature makes the crop late, and hence badly drained soils are cold and late; perfectly drained soils warm and early. But there is another circumstance that had better be here mentioned. Just as rain carries the soluble materials into the soil, evaporation during the dry season tends to bring these again to the surface, sometimes in the form of saline efflorescence. Should the soil not be porous and readily absorbent, owing to defective drainage, the first heavy showers, with the burst of the monsoons, will carry away these accumulations of soluble matter and thus gradually impoverish the soil.

Fall in Temperature *Conf. with paras. 56, 93, 104, 157, 283.*

Cold Soils.

Late Crops.

Surface Soluble Matter.

Soil Improvement.

115. These are surely considerations of the first importance to the tea planter that scarcely require to be further exemplified. It will at once be admitted, however, that the contrast between neighbouring gardens as to the commencement of the flushing season is often very striking. In many instances that difference may be accepted as a prognostication of defective drainage in the one as compared with the other. The complaint is often heard that one garden gives a poor return as compared with another, owing to its having a shallow soil. Drainage, while removing the surplus water and lessening the evils of evaporation, extends the arable depth to a far greater extent than could be accomplished by the expenditure of the same amount of capital in deep hoeing.

Indications of Defective Drainage.

Saving in Hoeing.

116. The descent of the water to the drains opens up the soil, carries air and heat down to the level of the drains, and distributes the soluble materials of the surface throughout the entire stratum permeated. This is accomplished through the all-important circumstance

that the ingredients of the soil (more especially its clay) act as a chemical filter. The warm water charged with the products of surface soil disintegration, and with air (*i.e.*, Oxygen, Nitrogen, Carbonic Acid, Nitric Acid, and Ammonia), is immediately seized upon and deprived of its food materials. Physical and chemical changes of the soil at once ensue. Poisonous decomposing organic matter is oxidised; the insoluble iron salts are converted into soluble food substances; and the nitrogen of the air is brought down to nourish and develop the indispensably necessary nitrating organisms of the soil. Physical modifications of the soil of a no less valuable character also take place. The continuous passage of water through the soil opens it up and thus tends to reduce it to a fine state of division. Its capillarity is thus vastly improved. By drawing the rain-water down surface wash is prevented. The arable depth of the soil being increased, the roots are able to penetrate to a greater extent and are thus protected by the additional layer of soil from the evil consequences of excessive surface evaporation, and they have the further advantage that occupying a larger extent of the soil they have increased facilities of obtaining food. Plants growing, therefore, on a well-drained soil are better able to withstand the effects of drought than those on a water-logged soil. A continuous supply of moisture is brought up to meet the necessities of the plant, the surface soil does not become caked, and in consequence rain when it does fall is at once absorbed instead of being carried away as surface wash.

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Chemical Actions of Rain-water: Oxidation. *Conf. with paras. 93, 136.*

Nitrating Organisms. *Conf. with paras. 297-317.*

Advantages to the Roots.

Surface Caking Prevented. *Conf. with para. 104.*

XX.—Water and its Relation to the Plant.

Vehicle of Conveyance of Food.

117. Turning now to the *second* consideration, namely, the functions water performs in the economy of plant life, it need hardly be repeated that it is the solvent utilized to facilitate the nutritious solid materials of the soil being absorbed by the roots. As already remarked, when rain falls on a properly drained soil, it carries down to the roots not only the mineral ingredients of the surface (rendered soluble through the action of the sun and air), but also oxygen in the form of air dissolved in the water and, an equally important necessity to the life of the plant, heat, absorbed from the atmosphere and from the warm surface soil. In its descent through the soil the water distributes these food materials of the plant and thus carries fresh supplies to every little fibril. It would be beyond the scope of the present article

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to trace out in detail the further functions of water, as it next ascends through the tissues of the plant, participates in the phenomena of digestion (or as it is called assimilation) and of transpiration (*i.e.*, perspiration and respiration), and finally once more descends to be built up in the growing tissues. But it may be said a free circulation of water in and through the soil is an essential condition of successful cultivation. The minute hairs on the rootlets suck up the moisture charged with nutritive materials. By exuding an acid principle they at the same time decompose and render soluble some of the ingredients of the soil that are necessary for the plant and which otherwise might not be rendered available. But in their search for moisture and food the roots are not passive agents obedient to mechanical or accidental environment. They are directly controlled by the leaves above ground.

Control Exercised by the Leaves.

Evaporation and Transpiration.

118. Transpiration (or as it might popularly be described perspiration) takes place literally *within* the tissue of the leaf and is thus a widely different phenomenon from the drying by evaporation of a piece of damp wood. It is a vital, not a physical, phenomenon. Small mouths called *stomata* are distributed over the epidermis of the leaves (of land plants), more especially on the under surfaces, and these open into passages that radiate through the cellular structure of the leaf. Water in the form of vapour is given off into these passages and makes its escape through the stomata so long as they remain open. But under certain circumstances they can be closed and transpiration thereby checked. The moment this takes place the demand for fresh supplies of moisture ceases and the rootlets with their absorbent hairs remain inactive or nearly so. Transpiration is necessarily very largely influenced by the conditions of the atmosphere in relation to the degree of humidity in the soil. But these are purely accidental phenomena controlled by physical attributes. A dry atmosphere brought to bear on the leaves of a plant whose roots are in a damp soil should cause rapid transpiration, conversely a damp atmosphere with the roots in a dry soil should retard transpiration. But it must not be forgotten that the circulation of water through the tissue of the plant is primarily in consequence of *its being the medium of conveyance of food*. If, therefore, its circulation was governed exclusively by such physical conditions as mentioned, the plant would be surcharged with food materials to an injurious extent and might be even forced

Circulation Dependent on Food Demands.

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to continue the function of assimilation during its periods of repose. It will thus be seen that vitality is and must be the power that utilizes and controls the physical laws that are brought to bear on the plant. **WATER in RELATION to PLANT.**

119. When transpiration is not desired the stomata are closed and the suction within the roots discontinued. But while that is so there can be no doubt that with plants as with animals circumstances often arise that induce excessive absorption of both food and liquid. When that takes place disease must of necessity supervene sooner or later, and when once the plant loses its activity, physical and not vital influences predominate until death occurs. It cannot, therefore, be doubted but that an abnormally damp soil is a condition to be carefully guarded against since it must of necessity expose the plant to an injurious resistance to the operation of natural laws. That the leaves may in consequence become charged with an excess of moisture (a sort of dropsical condition) seems highly probable. It might even be supposed that a too rapid evaporation (transpiration) would injuriously lower the plant temperature. Every one who has given the subject any degree of study is familiar with the sickly appearance of land plants growing on an over damp soil, and it is possible the sun blistering of the leaves to which tea planters often allude is due to this circumstance.

Excessive Supplies.

Resistance to Natural Laws.

Disease.

Sun Blistering. *Conf. with para. 818.*

120. It will thus be seen that there are good reasons for the affirmation that drainage is undertaken with a two-fold purposes, *viz.*, to remove excessive moisture and to increase the culturable depth as well as to improve the physical and chemical conditions of the soil. It is a mistake, therefore, to suppose that under any circumstance a perfect system of drainage is calculated to dry the soil abnormally and thus to expose the crop to the evil consequences of drought. Actual water only is carried away by drains, and before the excess can reach the channels of exit a far greater depth of soil than would have been the case otherwise has been raised to the point of saturation. The capillarity of the soil is vastly improved by drainage no doubt, but the affinity for water (possessed more especially by its component proportion of clay) is so strong that the presence of an elaborate system of underground drains will not deprive it of its moisture. The deeper portions of the soil part reluctantly in fact with their moisture, and do so only at the demands of surface evaporation, not underground drainage. Evaporation is a direct disturbance

Two-fold Objects of Drainage.

Actual Water Removed.

Improvement in Capillarity. *Conf. with paras. 63, 113.*

Soil Moisture Removed by Evaporation.

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scarce, cannot be doubted. But that tea should not be grown and will certainly not pay under such circumstances, is equally certain." Truisms of this nature are of necessity the result of defective knowledge of actual circumstances. Any one familiar with the tea districts of Assam, at the present day, will agree that artificial drainage is essentially necessary with at least one-half, if not three-fourths, of the land now under the crop. Moreover, drainage as a method of increasing the depth of arable soil has been entirely lost sight of in opinions such as those quoted.

Drainage Imperative with one-half Assam Gardens.

127. **Mr. F. Linde,** *Tea in India* (1879), says, "A regular system of drainage in low lying or flat lands and longitudinal drains on hilly lands are indispensable." The drains usually seen on hilly lands are made, for the most part, to catch the soil of surface wash not with the object of preventing a flow of water over the surface. In some case pits are dug in alternating rows across the face of the slope, a practice introduced from Japan.

Drainage Indispensable.

Drainage on Sloping Land. *Conf. with para. 156.*

128. **Mr. Samuel Baildon,** *The Tea Industry in India* (1882), in his chapter on the admitted depreciation in the quality of Indian teas, alludes to the constant drain on the soil with no recuperation as the undoubted cause. While he does not apparently recognize drainage as one of the most valuable aids to improvement of the soil, makes the following observation :—"Extraordinary results have been obtained by ample draining and heavy pruning combined ; but planters cannot achieve victories without labour."

Depreciation in Quality of Tea. *Conf. with paras. 214, 271-5.*

129. **Mr. G. M. Baker,** *Tea Planter's Life in Assam* (1884), enumerates "bad drainage" under the heading of "The enemies of the tea plant." "With bad drainage," he says, "there can be no hope of a successful future for any garden. The drainage difficulty used to be surmounted by making all gardens on the side of a hill ; in fact, every one of the old gardens was made in this way, and it took many years before the possibility of growing tea on the plains dawned upon the somewhat dense minds of old planters."

Bad Drainage an Enemy of Tea Planting.

130. **Professor Wallace,** *India in 1887*, gives a short account of tea cultivation, but makes no allusion to drainage.

131. **Notes on Tea in Darjeeling by a Planter** (1888) is the title of an interesting little book that contains many practical and useful hints. "In draining your flats," he says, "cut cross drains as well as long ones about 3 feet deep, and where embankments and raised drains

Open Drains Embanked.

are made, kill off all crabs that are to be seen as they bore through the walls and sometimes flood the flats. If it is only water from *Jhoras* or springs you want to drain, embanked drains are much the best, as deep drains will drain the little moisture there is in the soil in April off, and every drop is then wanted, so do not cut unnecessary drains."

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Open Drains Dry the Soil.

132. **Dr. J. Augustus Voelcker,** *Report on the Improvement on Indian Agriculture* (1893), under the heading of points of defective knowledge regarding tea cultivation, mentions the extent to which drainage may be requisite as a subject that will have to be looked into.

133. **Mr. M. Kelway Bamber,** in his work on the *Chemistry and Agriculture of Tea* (1893), was one of the first authors of special books on tea cultivation who gave the subject of drainage any serious thought. Most of his remarks are valuable and to the point, though I am satisfied he did not urge the matter with sufficient force. Indeed he qualifies his recommendations in almost every direction, as for example by the following :—"Of course it is not all soils that require drainage and much harm might be done by adopting it in every case; easily friable open soils with a free sub-soil, from which the water can easily percolate to a lower level, would certainly not be benefited by it but the reverse." Personally I should hesitate before saying that any soil could be injured by drainage, though I would freely admit that no great advantage might ensue from certain land being drained. If it has been ascertained, for example, that the sub-soil of a plot of land is thoroughly drained naturally, and that the arable portion above is sufficiently deep for all necessities or could not be deepened by artificial drains, then I should concur with **Mr. Bamber.** The majority of modern European writers on the subject of drainage might almost be interpreted as saying that it is next to impossible to injure land by draining it.

Over Drainage Urged.

Conf. with next page.

Next to Impossible to Injure Land by Drainage.

134. **Mr. David Crole,** *Tea its Cultivation and Manufacture* (1897), the most recent and least practical of Indian authors on tea-planting, while neither discussing the advantages of drainage nor attempting to indicate the methods that might be pursued, alludes to the subject as if by accident. "*Nullahs* or drains, I am of opinion, should run between the rows of tea at intervals of about 30 feet, if the labour can be spared for it; more especially should they be at such frequent intervals in low-lying localities, or situations exposed to

Drains to be made if Labour Available.

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the frequently disastrous effects of floods. The men have to excavate these drains with their hoes and a day's work consists of the digging a trench from 24 to 30 yards in length, 1 yard in depth, and of the width of a hoe, *i.e.*, at least 9 inches in breadth." As if conscious of having by the above passage too summarily dismissed the subject, Mr. Crole again reverts to it in two other paragraphs, thus :— "Stagnant water is fatal to the proper growth of tea, and so tea land must be out of the reach of inundations. It must be borne in mind, however, that friable, open soils, with a free sub-soil, and situated on a fairly high level, would receive actual harm from artificial drainage." He thus endorses Mr. Bamber's views and then continues :—

Stagnant Water Fatal.

"Theoretically, the deeper the drains are cut and the more there are of them, within reason, the better (subject to the above limitation) ; but in practice it will be found that the small drains should be between a yard and 3 feet 6 inches in depth and about 20 to 40 feet apart, according as to whether the soil be stiff or light ; and, moreover, they should be kept clean, and the silt and weeds cleared out every year, if necessary." In still a further place he returns to the subject : "It is, of course, very important to get a perfect drainage system and a good flow for the water." He offers now no suggestion as to how or in what way a "perfect drainage" is likely to be secured.

A Very Different Opinion Advanced.

Perfect Drainage Important.

135. Both Mr. Bamber and Mr. Crole speak of drains as being of most service when from 3 feet to 3 feet 6 inches deep. It would be interesting to know to what extent lateral or feeding drains exist in Assam that materially exceed 2 feet in depth. By way of contrasting with half-hearted opinions of the nature quoted, it may now be useful to give here a passage from a paper recently published from the pen of the late Mr. William Pringle. "The evidence available shows that there is always an improvement in the yield of the land where it is thoroughly drained. The ratio of improvement is usually not less than 20 per cent. on soils where the natural drainage is fairly good, and in the case of moors and swamps the land is improved from a state in which it would not grow food stuffs of any particular value to a condition of first class fertility."

Improvement with Artificial Drainage even when Natural Drainage is Good.

136. Mr. E. C. Schrottky published in 1878 "*A Series of Articles on Agriculture with special reference to Tea-Planting*" and one of the

chapters of that most useful little pamphlet deals with "Land Drainage." With perhaps the exception of the first edition of the prize essays, all the works mentioned in the foregoing remarks were published long after the appearance of Mr. Schrottky's pamphlet.* And yet only one writer (Mr. Pringle) urges with anything like sufficient force the adoption of thorough drainage as essential to successful tea-planting. This is all the more surprising since Mr. Schrottky's words are so full of meaning that one would have expected that in the twenty years that have since passed his recommendations would by now have been accepted axioms with every planter. It is perhaps needless for me to attempt to give passages from Mr. Schrottky's paper to show how completely he understood the true value of drainage. I commend the pamphlet to the planting community as well worthy of careful study. In one passage he refutes the idea that drains dry the soil injuriously in these words, "the drainer's object is to remove stagnant water from the soil only in order to give access to more water." "Most soils are drained, *not so much to get water out of the land as to get it into the land.* More water will pass through a drained than through an undrained soil; drainage opening thoroughly even the most tenacious soil, giving a free passage to water through it and thus securing to it the entire rainfall, part of which before, on all but sandy soils, found its way over the surface of the land into ditches and *nullahs*, carrying away with it some of the most fertilising elements of the soil." "It is a very common notion, especially among tea-planters, that rain when it comes down in heavy showers is injurious and should be carried off the land as soon as possible. They do not consider that rain-water contains most valuable manurial elements, and that the luxuriant vegetation of the tropics is due, to a great extent, to the presence of these in every shower that falls."

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Drains do not Injuriously Dry the Soil.

Drains Carry Water into the Soil.

Manurial Value of Rain-water.

Conf. with paras. 93, 116.

137. It may perhaps be admitted, from the perusal of the foregoing remarks, that it was unfortunate the writers of Essays and Manuals on Tea-planting did not recognize the importance of drainage. Had they even urged that in the laying out of an estate and in the

Rows of Bushes in Relation to Natural Drainage.

Conf. with paras. 144 and 151.

* The above remarks were page-proofed before my attention had been drawn to the chapter on Drainage in The *Tea Planter's Vade Mecum* published in 1885, pp. 61-64. In many respects I agree with the views there advanced, but cannot accept "cross drains of only 1½ or 1 foot deep by 2½ feet wide at top."

SUCCESSFUL DRAINAGE.

Rows of Bushes.

direction given to the rows of bushes, a direct and fixed relationship should be established to the natural drainage of the soil, much good would have resulted. We should have heard nothing of the controversy as to whether the rows should run east and west, north and south, or diagonally to the sun's path. They would have been so arranged that drains, should they have subsequently become imperatively necessary, could have been run between the rows as their natural and proper positions. But it was of primary importance from the earliest undertakings, as it is to the present day, that in laying out an estate spaces should be reserved for drains quite as much so as for roads. If found unnecessary these reserve spaces could subsequently have been planted or, if necessary, furnished with drains connecting on to and completing a preconceived system. In surveying the land for a new estate or new extensions, the survey officer should be directed to take the water levels with the greatest care and to indicate on his plan the trunk and mains with their chief tributary feeder or connecting drains, required to secure a perfect drainage. The planter with such a plan before him could then easily decide the direction of the rows of bushes and the spaces to be reserved for possible future lateral drains to carry surplus water from the various undulations of the soil to the connecting drains. But it is very likely that the total absence, in the past, of any preconceived plan of drainage may be employed as an argument against a complete reformation of the older gardens, in this aspect of tea cultivation.

Spacing for Drains. *Conf. with para. 165.*

Objections likely to be Raised.

XXII.—Conditions of Successful Drainage.

138. These considerations and recommendations lead naturally therefore to the study of the means by which so very great advantages may be attained, namely, the methods by which water may be most freely distributed and the excess most conveniently removed. Rivers and streams are the great arteries and veins in the circulation of water. Rain-water will percolate through most soils and appear again on the surface in the form of springs.

Springs.

139. Artificial drainage may be said to be improved facilities in the conveyance of surplus water to the rivers and the substitution of a better sub-soil drainage than may happen to exist in the plot of land under consideration. In other words, improvements in the outflow and in the underground currents. Let it, however, be added these must be developed essentially on the lines of existing natural

Artificial Drainage.

Natural Conditions.

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conditions. A successful system of artificial drainage therefore consists of:— SUCCESSFUL DRAINAGE.

1st. Trunk drainage—that is to say, improvements in the natural outfall such as deepening, straightening or embanking local streams and the construction of ditches or canals to convey the water direct from the area to be drained to the outflow. **Trunk Drains.**

2nd. Underground drainage—that is to say, the provision of a system of underground channels or drains intended to convey surplus water to the canal that connects with the natural outfall. The water is mechanically as it were drawn down through the soil in consequence of the facility of escape provided by these drains. The depth of soil down to the level of the drains has first, therefore, to be saturated before any discharge can take place, so that drains regulate sub-soil humidity. **Sub-Soil Drains.** **Regulation of Humidity.**

140. It will be evident from these propositions that the latter without the former would be worse than useless, but that the former without the latter might under certain circumstances be quite sufficient. Drains are, in other words, artificial improvements in the sub-soil movement of water towards the outflow. The natural drainage in a plot of land may be perfect so far as the peculiarities of the soil and conditions of the sub-soil are concerned. It may in fact be practically an island within a quagmire, and its fertility depend therefore on the provision of sufficient and complete trunk drainage. With a very large percentage of Assam gardens I believe the former may be a more pressing necessity than the latter. It is in fact to be feared this necessity has very largely been lost sight of in the selection of land to be thrown under tea. Many gardens, especially those on grass lands, are almost on a level with the surrounding rice fields, the annual inundation of which not only stops all outflow but raises the sub-soil level of excessive humidity to a ruinous extent. Where gardens are on higher and undulated land the *hullahs* or lower portions should be carefully surveyed and their levels ascertained in relation to the natural outflow. These should then be connected by drains sufficiently deep to act as the chief tributaries of the main current. But in many cases it would seem imperative that the outflow should be carried to some distance instead of being discharged into the nearest stream or surrounding rice land. The annual water-logging for months together of many gardens (or large portions of them) through the **Trunk Drainage of Primary Importance.** **Survey of the *Hullahs*.** **Cleaned out and Connected by Drains.**

SURFACE DRAINAGE.

Water-logged Land.

local stream obstructing the outflow is a fruitful source of many evils. It is generally held by chemical investigators that stagnant water in a soil checks the formation of nitrates and gives origin to several poisonous compounds. It is thus most undesirable that tea land should be water-logged even for comparatively short but annually recurring periods.

Engineering Difficulties.

141. But I am fully aware the contention that a more perfect system of drainage is indispensable to the future of tea cultivation, raises engineering difficulties, that in fact this very suggestion introduces a large and a difficult problem. I am convinced, however, that sooner or later that problem will have to be dealt with, if the evils of defective drainage are to be faced.

XXIII.—Assam Method: Surface Drainage.

Shallow Open Drains.

142. A system of surface drainage has become general in the tea districts of Assam. Trenches are dug at regular distances throughout the garden and for the most part parallel to each other. These are on the average about 9-12 inches broad and 18 inches to 2 feet deep, and I believe only rarely of a greater depth. In fact I venture to think I am correct in designating these as a system of surface, not subsoil, drainage. I examined them with the utmost care, and while I admit most willingly that they do a certain amount of good, feel satisfied they fall far short of the actual necessities of many estates.

Drains Laid out Subsequent to Planting Bushes.

They have been made in the majority of cases long subsequent to the date at which the bushes were planted out, and, owing to the fact that to place them in conformity to the requirements of the land would have necessitated the uprooting of a large number of bushes, they have been run between the rows and in some cases, I am afraid, across the natural drainage.

Uprooting Necessary. *Conf. with paras. 35, 70, 77, 164, 211, 225, 276, 280-1.*

Drains Passing over Undulations.

It is not uncommon to find these surface drains extending perfectly parallel for hundreds of feet up and down, over every undulation of the soil, without the slightest deviation or conformity to existing conditions and necessities. In order to allow the current to pass over the higher parts of the estate, these drains are in some places made very deep, at others shallow. But I submit that, while water no doubt may flow along them, they very frequently, I am afraid, obstruct the natural percolation of the soil. This statement may be abundantly demonstrated by the fact of the faces of the drains annually falling in on the side opposed to the natural flow. A drain 200 or 300 feet in length of

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the dimensions mentioned could never suffice to carry the water that should find its way there, provided such drains were fulfilling the purpose intended. But I am afraid that in many instances the idea that these drains were even primarily constructed for the transmission of water has been lost sight of, for they might more correctly be described as cess-pools. I may mention one instance where this was exemplified to a ridiculous extent. A large plot of land where the soil was water-logged had been surface drained in each direction between every third row of bushes until, as I told the manager, he had made a land and water draught-board of the plot. On enquiry as to the provision of a trunk drain to the outflow I found none had been made and the system of cross drains had been gradually worked into the parallel arrangement that radiated around this specially low portion of the estate.

SURFACE DRAINAGE. Cess-pools. *Conf. with para. 156.* No Outflow.

143. Examples of this nature are fortunately, however, but exceptional, and on the whole the surface drainage now fairly general may be said to have improved some Assam estates. But I think it as well to emphasise the fact that at best it is only a system of surface drainage not very different from what I have already characterised as street, in contradistinction to agricultural, drainage. In many gardens the managers are fully aware of this fact and bank up the earth on either side of the drains and also, just before the commencement of the rains, give the surface soil a heavy clod hoeing. By these means it is held that the water is made to percolate through the soil and to find its way to the drains without washing over the surface. I find, however, that Mr. Bamber takes a very different view. While accepting the present system of surface and open drainage as suitable to the hand cultivation that prevails, he adds, "The soil which is removed from the drains at the time of digging, and when being cleaned, will be found of much benefit to the bushes around which it is thrown, both as a manure and as a means of checking the growth of weeds for a time. It should always be spread as evenly as possible at some *distance from the sides of the drains so that the soil may slope towards, and not away from them*, and care should be taken in hoeing, that a few inches of uncultivated soil should be left on either side of the drain to prevent the disturbance and falling in of edges." In the above quotation the

Surface Flow Prevented. *Conf. with paras. 94, 96, 116, 124, 127.* Drains Banked up. Compare with Tea Planter's *Vade Mecum*, pages 62, 64. Lateral Encasing Walls. *Conf. with paras. 144 and 149.* Land Sloping to the Drains.

SURFACE DRAINAGE. Embanking Drains. Percolation through the Soil.

italics are mine and the words have been so rendered in order to draw attention to an opinion to which I take exception. Everything should be done to cause the water to percolate through the soil. Rather than that the land should slope to the drains I should recommend the sides to be banked up and the surface made to slope away from, rather than toward, the drains.

Open Drains Mischievous.

144. It may be instructive to contrast with Mr. Bamber's approval of shallow surface drains, Mr. Schrottky's views. "Speaking of Land Drainage," he says, "we must not be understood to mean the shallow surface drains which are now almost universally used in tea and coffee plantations, to carry off any heavy rainfall, as soon as possible, to the nearest river. Nothing could be worse than this; what we mean is, a thorough sub-soil drainage, acting 3 or 4 feet below the surface, and capable of absorbing into the soil all the rain granted by the bounty of nature, and either consisting of closed pipe, stone, or brush-wood drains, *or of open drains with good embankments to prevent all surface drainage.* Every precaution should be taken to retain in the land all the rain that falls on it, until it has had time to percolate through the soil and impart to it all the manurial elements it contains." So again he says, "It is a very common fallacy entertained by planters that shallow drains, say 15 to 18 inches deep, are as effective as deeper drains. This notion should be got rid of as soon as possible, for it is replete with mischief." "Of what use can shallow drains be, 15 or 18 inches deep, generally without embankments?" "Their only use, as far as we can see, is to encourage surface drainage and wash out the most fertile portion of the soil. Some tea gardens have been ruined by shallow drains."

Surface Drainage Prevented. *Conf. with para. 143.*

Shallow Drains. *Conf. with foot-note to para. 136.*

These words were penned close on 20 years ago, and I am afraid they are very nearly as true to-day, of the Assam gardens, as ever they were, except that the ruinous action of open shallow surface drains has been continued to a greater extent and the disease and loss of vitality foretold by Mr. Schrottky, become a reality with many of the older concerns.

Ruinous Loss of Vitality.

Feeding or Lateral Drains.

145. According to the most generally accepted opinion in Europe, a useful and effective system of feeding or lateral drains should be at least 3 if not 4 feet below the surface, so that the drainage becomes sub-soil. That is to say, the water derived from rain is made

Drainage of Tea Gardens.

to penetrate through the soil to a depth sufficient to reach the deepest roots before it is removed. If drainage 4 feet below the surface be deemed essential in the cultivation of annual and herbaceous crops, it follows that it is doubly more so with a perennial and bushy crop such as tea. Thus even admitting that by banking up the soil and clod hoeing, a surface flow to the drains may be prevented, the system of drainage that prevails in Assam tea gardens is one that must create a very shallow percolation of the soil. Hence it may reasonably be concluded that either the open drains described do not fulfil the purpose of drains, or if they do, they remove the water at a point above the level of the major portion of the young absorbent roots of the tea plant and very possibly leave the soil water-logged below their level.

SURFACE DRAINAGE.

Shallow Percolation.

146. I am afraid also that an elaborate system of open drains tends to dry the soil to an injurious extent. Mr. Bamber, it will be observed, recommends that a strip of soil (which in practice is from half to a foot in thickness) should be carefully preserved on the sides of the drains. This recommendation is very generally followed with the result that these lateral ridges become retaining walls. After a few seasons they become practically impervious to water. They are then coated with ferns and other vegetation, and I fear harbour to a very large extent the hibernating stages of a good many of the tea pests.

Drying of the Soil. *Conf. with paras. 147 and 162.*

Pests Harboured in Open Drains. *Conf. with para. 720.*

147. But Assam falls far short in extravagance in this respect to a garden visited by me in Kangra. There the drains are not only 4 to 6 feet deep but nearly as wide. At first it looked as if they had been intended as secret passages constructed for some ancient strategic necessity. I was told they were drains that served the further purpose of furnishing additional surface soil to the intervening cultivated plots. I have seen nothing to compare with these, except perhaps the mulberry beds in the Bogra district. The stunted bushy cultivation of that plant, could not be accomplished unless the roots were above the level of the annual rice-field inundation. Immense labour was accordingly expended, the soil was excavated from strips of land some 8 to 10 feet in breadth and thrown up on intervening spaces of like dimensions. Elevated beds were thus formed some 4, 6 or 8 feet above the intervening portions. On the lower spaces rice was grown and on the higher mulberry. But, can it be matter of surprise that, where such conditions were necessary, the industry stood

Unnecessarily Large Open Drains.

Mulberry Cultivation.

Drainage of Tea Gardens.

SURFACE DRAINAGE.

a poor chance of becoming either lucrative or lasting. The mulberry beds are being abandoned and the silk-rearers are in a state of poverty.

148. I have little hesitation, therefore, in affirming that open shallow drains of the nature indicated, do not serve the purpose of sub-soil suction, but, on the contrary, encourage a surface wash of the rain-water toward these superficial channels of escape. I should not indeed be surprised to find that in many cases, as already suggested, these drains entirely obstruct the natural sub-soil percolation and convert the intervening plots into water-logged basins. That they dry the surface abnormally I have little hesitation in affirming. Let any one work out the amount of soil (on a level with a certain proportion of the roots) that is exposed in these drains to the merciless heat of the dry season, and he will be surprised at the very large percentage obtained. It should be recollected that in a healthy soil a complete adjustment is constantly taking place from particle to particle. When the roots of the plant abstract moisture from one spot, all adjacent portions immediately part with the necessary amount of humidity to restore the balance. So in the same way if an open drain has its sides and bottom dried abnormally from exposure to the sun, the adjacent soil parts with its moisture to replenish the loss and restore the equilibrium.

Obstruct Sub-Soil Percolation. — *Water-logged Basins.* — *Dry the Soil Injuriously. Conf. with paras. 146, 162.* — *Equilibrium of Soil Moisture.*

149. The simple fact that the sides of these drains are never cultivated, increases the difficulty, for a cultivated surface suffers less by evaporation than an uncultivated one, while it is at the same time more absorbent. If I am not, therefore, very much mistaken, the injury done to the tea land during the hot season, by these elaborate openings into the soil, must be quite as great as the damage they occasion, through the tendency of a surface wash toward them during the rainy season. That they certainly are not sources of moisture to the tea, may be abundantly demonstrated by the fact that the roots are never found to penetrate through or even approach the enclosing walls of these drains. That they do not deepen or improve the quality of the soil, may be still further seen by the fact that the rows of tea bushes hard by manifest no superiority to those at a distance. And this last observation is significant, for most people are familiar with the bands of bright green grass or richer corn that in Europe correspond to the pipes that are lying 4 feet below the surface of a well-drained field.

Lateral Retaining Walls. Conf. with para. 143. — *Demonstration of Value of Drains.*

Drainage of Tea Gardens.

XXIV.—Position of Drains.

POSITION of DRAINS. Outflow.

150. In most Assam gardens the construction of *receiving drains* to connect with the main outflow, has no doubt been carefully considered, but in some few instances, examined by me, receiving drains had been entirely neglected or placed in wrong positions. The receiving drains should of course occupy the lowest portion of the ground and the *sub-soil drains* should follow the line of the greatest ascent and run parallel to each other or converge toward the bottom, as necessity may dictate. It is no doubt sometimes also of advantage that the feeding drains should pursue a diagonal course, and thus enter the receiving drains at an acute, not a right, angle. Undulating land can never be satisfactorily drained by a fixed direction being laid down for the sub-soil drains, in defiance of surface configuration. Each depression must be drained by itself and have a central receiving drain traversing the lowest portion and connected with all the other receiving drains. It is essential also for a rapid flow of water that the sub-soil (or lateral) drains on either side of the receiving drain should not discharge opposite each other.

Adaptation to Configuration.

151. *Distance Apart.*—As to the distance apart of lateral or feeding drains, the following table was given by the late Mr. Pringle (derived from Mr. Dempsey, C.E.) as the final results of English experience :—

Lateral Feeding Drains. *Conf. with foot-note to para. 136.*

Nature of Soil.	Depth of Drains.	Distance apart.
Compact.		
Tenacious clay *	2 feet 6 inches.	15 feet.
Friable clay	2 „ 9 „	18 „
Soft free clay	2 „ 9 „	21 „
Medium.		
Clayey loam	3 „ 0 „	21 „
Gravelly	3 „ 3 „	27 „
Friable	3 „ 3 „	30 „
Porous.		
Light loam	3 „ 6 „	33 „
Sandy	3 „ 9 „	39 „
Light gravelly sand	4 „ 0 „	51 „
Coarse	4 „ 6 „	60 „

Drainage of Tea Gardens.

POSITION of DRAINS.

Fall in Lateral Drains.

Three feet should be the minimum depth of lateral drains, on good average tea land, the mains or connecting drains should be correspondingly lower. The lateral drains should, if possible, have a fall of 1 in 100 or 1 in 150; Mr. Schrottky fixes the minimum at 1 in 220. Mr. Pringle, who was for some time Agricultural Chemist in Coorg (under Messrs. Matheson & Co.), seems to have been in favour of open drains for coffee and tea plantations owing to the liability of closed ones being blocked by the roots. He adds, "wing drains need not exceed 1 foot 6 inches at top by 4 to 6 inches at bottom. Depth is the important factor, not width."

Depth the Important Factor.

Nature of Sub-Soil.

152. ***Nature of Sub-Soil.***—In Europe the practice prevails of digging deep holes in order to study the nature of the sub-soil before commencing to lay out drains. So far as I was able to ascertain from the study of the cuttings made for railways and roads, the better class tea soils of Assam are often of an enormous depth and of a uniform nature throughout, namely, a rich red or yellow clayey loam. This circumstance no doubt may necessitate certain departures from European agricultural practice. But that open drains should be made professedly to facilitate surface wash, as I was, on more occasions than one, informed was the case, is a very radical departure indeed. I was repeatedly assured that the natural drainage was quite sufficient. This was more especially said to be the case when the drains were run across the face of sloping land instead of up and down or diagonally.

Open Drains made to Receive Surface Wash.

Bushes Rising out of Ground.

Conf. with para. 216.

153. ***Bushes Rising out of the Ground.***—While not doubting that there may and indeed does exist in many cases a distinct necessity for terrace cultivation, I would most emphatically take exception to the statement that drainage is unnecessary. Hardly a garden could be said to exist in Assam where surface wash does not or had not taken place. This is of course more especially the case on all land with a slight declivity. The bushes that once had been securely rooted in a deep soil may now be seen standing on the top of a cluster of roots, so that the stem, Mangrove-like, is 1 or 2 feet above the level of the ground. And this is by no means confined to sloping land, but may be witnessed on all flat land where free percolation does not take place. The surface soil has been washed away and the bushes thus made to rise as it were out of the soil. No more certain indication of ruinous surface wash could be mentioned.

Ruinous Surface Wash.

Conf. with paras. 94, 99, 116, 124 127, 157, 216, 271.

Drainage of Tea Gardens.

POSITION of DRAINS.

Seeming Subsidence of Bushes.

154. ***Bushes Seeming to Subside.***—Interference with the natural drainage may, on the other hand, be seen to produce a subsidence of the soil around the bushes. At a garden in the Sibsagar district, visited on the 11th April, the observation was made that one-half of the estate on the north side of the Ali (or road) was much inferior to that on the south, and, moreover, appeared water-logged. It consisted of a heavy red sandy loam and was mostly under China and inferior *jat* Assam hybrid bushes. The water was seen to collect on the surface into pools, and owing to the impervious nature of the soil to finally gravitate towards the bushes. The roots then served to conduct it below until, through this continual subsidence, the ground around the bushes become the lowest portions. Large holes, often a foot in diameter and $1\frac{1}{2}$ feet deep, were thereby excavated with smaller passages leading from bush to bush. This condition was frequently observed in gardens where the drains might be said to follow methodical system of parallels regardless of the local undulations and natural drainage of the soil.

Roots Conducting Water below.

In a garden with impervious soil where water tends to flow on the surface and to use the stems and roots as conductors to the sub-soil, thorough drainage and even drill hoeing would appear imperatively necessary. Though due doubtless to a slightly different state of affairs to that in which the bushes instead of appearing to sink into depressions are seen to stand above the surface, both denote defective drainage.

Defective Drainage Indicated.

155. ***Sites of Assamee Villages.***—In this connection I may also mention a very evident example of defective drainage. Planters are familiar with the fact that plots of land here and there, in very nearly every estate, are barren or practically so. These are generally explained as being old sites of Assamee villages or coolie lines. It is a well ascertained fact that land on which human beings have resided for any length of time is sterile. This is, however, not due entirely to the accumulation of poisonous organic materials. It is a direct consequence of the soil having been so compacted that it is impervious to both water and air. Such soils may be repeatedly deep hoed and even richly manured, but will still take many years before the tea bushes planted on them show any indications of activity. Let one or, if necessary, two good sub-soil drains be run through such plots, and in a comparatively short time they will be seen to have been converted

Old Assamee Villages.

Conf. with para. 312.

Drainage Indicated.

POSITION of DRAINS.

into pieces of the very best soil. The oxygen of the air (drawn down by the water) will rapidly convert the accumulations of organic matter from a poisonous to a highly nutritious condition. The water both through its chemical and physical properties will open up the soil and render it arable to the needed depth, and thus drainage as a means of tillage will be demonstrated to succeed where the hoe had failed absolutely.

Drainage of Hill Sides. *Conf. with para. 127, also Tea Planter's Vade Mecum, p. 63.*

156. *Sloping Land.*—Sloping land, it is often said, cannot be thoroughly cultivated because of the very certain removal of the loosened soil that would take place by surface wash. Far from drainage therefore, being unnecessary on sloping land and hill sides, it is just in such situations where it may be of most pressing urgency. A rapid vertical percolation into a liberal sub-soil drainage will stop surface wash more effectually than terrace cultivation or Japanese cess-pools to catch the soil.

XXV.—Sub-Soil or Pipe Drainage Recommended.

Sub-Soil Drainage Checks Surface Wash.

157. The most effectual check in fact to surface flow of water is a liberal and deep percolation and rapid sub-soil removal of surplus water. Indeed I attribute the backwardness of many gardens or portions of gardens as due primarily to the cold, sour, and water-logged condition of the soil. I would strongly recommend experiments to be made in sub-soil draining, especially with heavy soils of great depth and with shallow sandy loams where surface wash has been clearly established.

Increase the Arable Depth.

Sandy and Porous Soil with Low Organic Matter. *Conf. with paras. 96, 113, 285, 291.*

I was taken over a garden in Upper Assam where the yield had fallen off within the past few years by one-half its former record. The decline had been steady for a number of years back. Various reasons were assigned by the superintendent for this circumstance. The soil was so extremely sandy and porous that open drains, such as had been introduced in other estates, could not be maintained. The real explanation no doubt is the shallowness of the soil and the continuous loss during the past number of years, through surface wash. Sub-soil drainage would, in a case of this kind, induce a vertical instead of a lateral flow of water and thus give a greatly needed deeper fertility and humidity than at present exists.

158. Cultivation of the nature pursued in Assam must tend to break up the ingredients of the surface and thus gradually increase

the evil tendencies by the production of a soil that cannot retain sufficient moisture to meet the necessities of the crop. No wonder therefore when an originally light sandy loam after 40 or 50 years' continuous cultivation of the same perennial crop begins to show signs of losing its fertility. It has been hoed some eight or ten times every year without the slightest effort having been made to deepen the arable stratum. Year after year its soluble materials have been brought to the surface and washed away by the heavy and sudden rainfall that often alternates with hot dry days. No manure has been given, no rotation of crops pursued. A persistent system of hoeing has been looked to as the one requirement for a never ending production of tea.

PIPE DRAINAGE. **Surface Tillage.** **Surface Wash.** **Persistent Hoeing.**

159. ***Objections to Pipe Drainage.***—While fully conscious that my views on the matter of sub-soil drainage are likely to be opposed to those of the majority of tea-planters, I think it as well nevertheless to impose thereby no restrictions on my freedom of utterance. But it may be as well to record here the opinions of the few authors who have expressed themselves on the subject of pipe drainage:—

Stone Drains. ***Conf. with Tea Planter's Vade Mecum, p. 63.*** **Brush-Wood Drains.**

Mr. Schrottky comments on the subject in the following passage:—"Pipe drains cannot be used, as the roots would invariably choke up the pipes, but closed stone or brush-wood drains are practicable." I fear that in Assam stone drains would be an impossibility from the fact that there are no stones to be had in tea gardens. Brush-wood drains I certainly could not recommend owing to the fact that they would most certainly harbour and encourage the development of white-ants. But to continue from Mr. Schrottky, "The fall in such drains, however, ought not to be less than 1 in 220. The drains will of course converge to the nearest river, *nullah* or *jheel*; where the plantation lies in a hollow and no outlet can be found for the drains, drainage can be often established by digging a few wells and establishing a connection between the surface and some porous sandy substratum. This plan will also answer where the garden is so surrounded by rice *khets* and villages, as to prevent access for the drains to any *nullah* or river. All drains should, of course, be constructed on the fundamental principle that water runs to the lowest level and a previously well-considered plan should underlie all operations." Mr. Schrottky's remarks on the subject of drainage into wells are worthy of careful consideration.

Fall in Lateral Drains. **Drainage into Wells.**

Drainage of Tea Gardens.

PIPE DRAINAGE. Objections.

160. Mr. Bamber narrates the objections to pipe drainage in the following passage:—"The question has been raised as to the possibility of using pipe drainage for tea, and so doing away with the open drains. Several advantages would be gained by its adoption, but there are also several objections to it, the most important of which is, that in the dry season the roots of the tea-bushes would certainly penetrate the joints of the pipes, wherever water was to be found, and rapidly choke the drain; and it would be very difficult to discover the exact spot where the stoppage had occurred, without opening the drain in several places throughout its length."

Penetration of Roots.

Vermin.

"Vermin, white-ants, etc., would also be liable to damage the drains, by excavating the soil below the pipes, when they would drop out of their proper level, and so prevent a free flow. In the case of such an accident the faulty spot would probably be shown by the water rising to the surface as a spring, during any very heavy rainfall."

161. The only other writer who deals with the subject of covered drains * for tea plantations (so far as I can discover), is the gentleman whose letters to the *Madras Mail* I have already placed under contribution, namely, the late Mr. William Pringle. "Open drains," he remarks, "are more suitable for plantations than closed ones laid with pipes, which are liable to be blocked by the roots of the trees."

Objections to Open Drains.

162. I have already detailed the chief objections that exist to open surface drains. One of the most important is the injurious drying of the soil that must take place. Were the lateral or feeding drains to be lowered to 3½ or 4 feet, they might, and no doubt would in that case give origin to a satisfactory sub-soil percolation, but their drying proclivity would only be the greater by the increased depth. I repeat drains are intended to remove surplus water, not to deprive a soil of its natural moisture. It seems to me, therefore, that in the Tropics the surface soil should not be exposed to any additional influences that may dissipate its humidity than occur naturally.

See letter by "A Novice," *Tea Planter's Vade Mecum*, p. 64.

I should like to know, however, if covered (pipe) drains in tea land had ever been tried. I came across no one in Assam who could tell me of any experiments in that direction, and consequently could obtain no evidence that they had been found defective in the way

Conf. with page 77.

* The *Tea Planter's Vade Mecum* says, the trifling rain-fall in England renders pipe drainage practicable: some of the tea districts would have to dispose of at least five times as much rain-water. Is this statement, strictly speaking, correct?

indicated by Messrs. Schrottky, Bamber, and Pringle. I am not prepared of course to say that these gentlemen have been reasoning on purely theoretical grounds, since in Europe the rule is laid down as absolute that drains must be kept at some distance from hedges or trees. But the tap root of the tea plant goes straight down into the soil, and the laterals to the best of my knowledge do not cover more than a space of 5 feet in diameter. The greatest diameter, moreover, occurs at about 2 feet below the surface, lower down the laterals become shorter and shorter until they practically disappear. It is customary to say that the roots of a plant spread below ground to a slightly less extent than the branches above. The dome of leaves and branches is intended in fact to act like an umbrella conveying the rain to the part of the ground as near as possible right above the young growing roots.

PIPE DRAINAGE.

Relation of Roots to Branches.

163. ***Scheme for Pipe Drainage.***—To drain effectually and at the same time to obviate the danger of the roots disturbing the pipes it no doubt would be necessary to uproot one row of bushes where the required distance apart did not already exist. I do not suppose, however, that with bushes 7 feet apart there would be the slightest danger of underground drains, at a depth of 4 feet below the surface, being in any way injured by the roots of the tea. I have had many tea bushes partly or entirely dug up, in order to see the extent to which the roots penetrate and spread laterally. I have no doubt but that with good drainage and a rich sub-soil, the tap root might descend 6 to 10 feet or even more, although I never come across a bush the main root of which materially exceeded 5 feet. Indeed I was greatly surprised at the shortness of the roots and at there being so very few of them as compared with the number of branches—a circumstance that is probably accounted for by the severe and constantly repeated pruning to which the plant is subjected.

Conditions Necessary.

Number and Extent of the Roots.

164. It would of course be disastrous to plant tea bushes on the top of drains, in the way wheat or turnips are sown in Europe. But not a few gardens in Assam, even at the present day, have their bushes 7 or even 8 feet apart in one direction. In most cases such gardens have been or are being interlined with young bushes. I have no doubt but that covered drains between every fifth or sixth row, in a garden of the nature indicated, would be perfectly safe. The land would be thoroughly drained and for many years to come would

Bushes must not be Planted on Top of Drains.

Drainage of Tea Gardens.

PIPE DRAINAGE.

entail no further trouble or expense on this score. Where bushes stand only 4 feet apart there no doubt would be some risk in the roots disturbing the pipes. Deep covered sub-soil drainage in that case might mean the uprooting of a row of bushes to allow of the drains being placed and maintained in position. But I think there can be little doubt as to the fact that defective drainage has largely to account for the rapid development of the blights and diseases of the tea plant. The improvement effected by good drainage would more than repay the loss sustained by the removal of the bushes necessary to allow of a complete system being introduced.

Uprooting of Bushes. *Conf. with paras. 70, 77, 142, 270.*

Spacing for Pipes. *Conf. with para. 137.*

165. I would strongly recommend all extensions or new gardens to be laid out in the future with provision for a liberal system of sub-soil drainage, in direct adaptation to the conditions of the soil and the configuration of the land. It would be no very serious loss, where the bushes are 5 feet apart, to plant each sixth row, or where they are 4 feet apart, each seventh row, 8 feet apart instead of 5 or 4 feet as may be the case with the others. Were this system followed, sub-soil pipes placed 4 feet below the surface and running along the middle of these blank spaces would approximately occur every 32 or 34 feet. The space above the pipes would be found convenient for the work people on which to place their children, also baskets and other collecting materials and agricultural implements that often are at present thrown down between the bushes and do considerable damage. These alternating strips might also be utilized for the cultivation of nitrogen giving leguminous crops. And indeed even should sub-soil pipes never be placed within them they would afford a greatly needed ventilation to the garden.

Supply of Nitrogen to the Soil. *Conf. with para. 313.*

Ventilation.

Causes of Disease. *Conf. with paras. 33-34, 273.*

166. From all I was able to learn in Assam the chief causes of the want of vigour and prevalence of pests might be said to be defective drainage, excessive plucking, absence of any rotation in crops, want of manure, and overcrowding. If I be correct in that opinion the loss of every sixth or seventh row of bushes would be of small consequence. The increased yield, due to the deepening and improving of the soil, would more than compensate for a loss even of so serious a nature as that proposed. But in my opinion the time is rapidly approaching when such losses will have to be accepted.

White-ants.

167. Mr. Bamber considers white-ants as likely to disturb pipe drainage. I cannot see how this could come about. In many tea

gardens it would be difficult to find a white-ant hillock anywhere. But apart from the fact that they would have to be fairly common in gardens now before they could be regarded as likely to prove a positive danger in the future, there are other circumstances that I think should instantly dispel that anticipation. I have had several ant hillocks out open in Assam and never found one yet in which the ants were more than 2 or at most 3 feet below the surrounding surface level of the soil. Their hillocks may be as much as 3 to 8 feet above, but they rarely penetrate to any great depth, though their lateral burrowings are often marvellously extensive. The mere fact that pipes would be damp and the ground around them porous and traversed by the water passing to the drains, would render such positions unlikely ones for white-ants to take up their abode. Were the pipes to be made of wood instead of clay it might be different.

PIPE DRAINAGE.

White-ants. *Conf. with para. 665(2).*

168. ***Cost of Pipe Drainage.***—I confess I can see no sufficient reason why tea gardens in Assam should not be pipe-drained.* The difficulties that exist are those alone incident to all departures from established usage, and once the subject has been viewed as one that must be surmounted, one difficulty after another will disappear. I am of course fully aware that pipe drainage would be expensive. Assuming that 6-inch clay pipes could be put down at 8 annas per running foot, and that it was found necessary to have drains every 30 feet, that would mean 1,450 running feet per acre, or R750 against R40 for the open surface drains at present in use. But I have repeatedly remarked, and desire here to reiterate, that my object in writing this report is to indicate the probable causes and possible cures of the tea pests., The financial aspects of the questions raised I leave to those whom it may concern. I would, however, point out that the expenditure for surface drainage is a frequently recurring one, while pipe drains, if successful at all, would be permanent. Moreover, they would discharge the object aimed at so infinitely more satisfactorily that I am fully convinced they would in the end be found economical rather than extravagant. If it will pay to drain wheat fields it ought surely to pay to drain tea gardens. Moreover, there is no reason why clay pipes could not be made locally and at a third the price estimated, or even less than that. But it is useless to argue on probabilities,

Financial Considerations. *Conf. with paras. 108, 129.*

Renewal of Drains. *Conf. with para. 169.*

Advantages.

* See Report of an experiment at pipe draining a Vegetable garden in Assam—*Journ. Agri.-Hort. Soc. Ind. Vol. IV. Proc. 11th July 1845.*

BURYING of PRUNINGS.

Experiment Necessary.

to me the suggestion seems well worthy of trial. I would, therefore, urge the owners and agents of tea gardens to accept this recommendation as one to be seriously considered. As I have shown it would not cost a very great deal to have 20 acres or so, drained in the manner recommended. Careful returns of the plot experimented with, if preserved before and after, would in a very few years demonstrate conclusively the utility and practicability of sub-soil drainage.

XXVI.—BURYING OF PRUNINGS IN DRAINS.

169. Before concluding these remarks on drainage I desire once more to take exception to another of Mr. Bamber's recommendations.

In Drains.

"It is the practice," he tells us, "on several gardens to bury prunings in the drains, after they have been open some years, and to dig new drains between the next row of bushes, utilizing the soil removed to fill up the old drains. This burial of the prunings, the leaves of which contain a large amount of nitrogen, is no doubt of much benefit to the bushes in the immediate neighbourhood; but, if the drains have been dug originally the right distance apart, it would probably be found more economical to spread the prunings evenly and trench them in with a double hoe than to incur the expense of re-digging all the drains."

By Trenching.

Position of Bushes made to Govern Drainage.

The mere fact that such a system exists of periodically changing drains from between one row of bushes to another shows that it is the existence of bushes that governs the position of drains, not the configuration of the land and nature of the soil. When once placed in their proper positions, drains should not be changed, unless through distinct indications of deficiency in the drainage. The pores of the soil having been so adjusted that water has found its way toward drains, in particular positions, a disturbance of those positions would retard for some time the percolation and thus do positive harm. Apart, therefore, from the expense of renewing many thousand feet of open drains, with no compensating advantage, there are distinct reasons why the practice should be discontinued.

Renewal of Drains. *Conf. with para. 168.*

Burying Prunings Recommended. *Conf. with para. 699.*

170. My chief objection to Mr. Bamber's remark on this subject lies, however, in the fact that, instead of condemning the habit of burying prunings as dangerous, he recommends it and, moreover, suggests an even more pernicious system of doing so than that to which he takes exception. But I regret to say Mr. Bamber is not singular in this

opinion. Most writers on the subject of the disposal of prunings either recommend that they should be buried or view with indifference the fact of their being buried. Colonel Money says, "Let all prunings be buried between the lines of plants, if possible, before the leaves have been withered. They make capital manure, but much of the virtue escapes if they are allowed to lie on the ground any time before they are buried." Mr. Crole says, "Heavy prunings are generally buried in trenches specially cut for them between the lines of tea, at intervals of two or three rows or more, in order to act as a sort of green soil manure; but as some planters fancy that this method does not conduce to the health of the plants, but makes them prone to blight in some unaccountable manner, the prunings are sometimes carried away and burnt." He then goes on to say that the men do the "cutting down as the heavy pruning is called, and the women the other lighter pruning. After the pruning is over—and it is always well to get through with it as soon as possible—the men double-hoe the soil; that is after turning up the top sod with the hoe, they hoe up the soil beneath, scrape the prunings into the shallow trench thus formed, and bury them below the sods of the next lot in front that they hoe, thus securing all the benefits from the manuring properties of the otherwise useless prunings."

BURYING of PRUNINGS.

Larger Prunings Trenched.

Smaller Prunings Hoed in.

171. ***Dissemination of Disease.***—But for the use of such expressions as "fancy" and "unaccountable" applied to a question of this nature, I should have regarded the burying of prunings as one that had only to be mentioned in order to secure that the practice would in future be rigorously prohibited. Even admitting that there is a slight manurial advantage by so doing, some of the most serious maladies to which tea is subject is thereby distributed all over the garden. It will pay the planter ten times over to incur the expense of purchasing a chemical manure, that will give to the soil as much, if not more, nitrogen and other materials than are contained in the prunings. By burying them he risks the perpetuation and extension of many insect and fungoid pests that harbour on the shoots when the periods of their inactivity occur.

Purchase of Manure Preferable.

172. In a garden in the Tezpur district visited by me in July, I pulled out of the ground many projecting twigs of partially buried prunings, and showed the manager, who was with me at the time, that these contained, in their active condition, the spore-bearing structures

Examples of Dissemination.

Red Rust. *Conf. with paras. 851-74.*

Burying of Prunings in Drains.

BURYING of PRUNINGS.

of "Red Rust." These prunings had been buried in the Autumn and had thus continued for months to distribute the disease. Red-rust had made its appearance in the garden a few years previously and had been spreading at an alarming extent, and no wonder since year after year, by burying the prunings the malady had been carried from affected to healthy bushes.

Thread Blight. *Conf. with paras. 839-50.*

173. On another occasion (in June), while examining a garden in Sibsagar district, the manager at my request dug the ground around a bush where thread blight was seen to run up the stem, as if extending from the roots. It was soon discovered, however, that it was spreading from buried prunings.

Root Fungi. *Conf. with paras. 875-81.*

Saprophytic then Parasitic.

Burning. *Conf. with para. 213.*

Drying Prunings Dangerous.

Ashes used as Manure.

174. I might multiply such examples, but the instances given will suffice to show that surface trenching of prunings is a most dangerous proceeding. If thrown into drains and completely covered with 2 to 3 feet of earth, the evils to which I allude might be greatly mitigated. But, as opposed even to this, it may be said, there can be no doubt, that the roots of the tea plant are often invaded by fungi that would seem to originate in the first instance on the roots of dead trees and other decomposing vegetable matter in the soil, being what the botanist calls saprophytic in the first stage of their existence (and thus harmless to living plants), but assume a further stage in which they are parasitic and kill the plants upon which they then live. Surely with possibilities of this nature it should be regarded, under every circumstance, as dangerous to bury tea prunings. They should be collected into heaps on the roadways and invariably burned, the ashes being scattered over the surface of the soil. And let me add that in gardens badly blighted, the burning should not be delayed until the prunings have dried. By so doing the blights contained on them mature rapidly in order to check their approaching destruction through the death of the prunings. Their germs are at once distributed and the evil it is desired to intercept is thus more widely disseminated than might otherwise have been the case. It is desirable that each day's prunings should be burned at once even should they be only charred and the leaves and twigs alone actually burned. In that condition they are comparatively harmless and the coolies might then, if they desired, be permitted to carry off the larger portions for firewood. Finally, when fully dried, the remainder should be completely burned and the ashes scattered on the garden soil as manure.

CHAPTER VII.

PRUNING.

XXVII.—Diversities in Pruning.

DIVERSITIES in PRUNING.

Objects of Pruning.

175. Pruning is an operation performed in horticulture to induce a plant either to assume a particular shape that it might not do naturally or to force it to concentrate its energies in a direction it certainly would not do if left to itself. In both instances, therefore, pruning may be viewed as an interference, on the part of the cultivator, with the habit of the plant, and hence unless prosecuted with intelligence may cause material injury.

As a result of accumulated knowledge in the sciences of Botany and Horticulture it is now known that, should the aim of the cultivator be to produce abundance of flowers and fruits, the plant must be encouraged to form healthy branches of a particular nature. So again it is a well-ascertained fact that should the object desired be the production of leaf, everything must be done to discourage the tendency to produce flowers.

Pruning for Fruit and Pruning for Leaf.

The system of pruning pursued in the orchard may be said accordingly, to be the very opposite to that in the tea garden. And it may at once be acknowledged that, with the exception of the propagation of ornamental foliage plants and the production of new forms of certain vegetables, English horticultural experience is of comparatively little value to the Indian tea-planter. This, it need hardly be explained, is owing, very largely, to the production of leaf forming so insignificant a part in the training given to the English gardener. It no doubt might be different with practical men who were familiar with the production of mulberry—a plant grown like tea purely and simply for the supply of leaf.

Conf. with para. 178.

Different Methods Necessary.

176. ***Prevalent Conditions.***—These explanatory remarks have been offered as in part accounting for the diversity of opinion and practice that prevails, even in one portion of the Indian tea districts (Assam), on this all-important subject. It would be comparatively easy to understand the existence of different methods in remote countries where perhaps diversities existed in climate, soil, and plant. But the state of affairs that prevails in Assam, to say the least of it, is often very perplexing. Hardly any two gardens could be said to be alike in

Pruning.

DIVERSITIES in PRUNING.

Shape of Pruning.

their systems of planting out, pruning and plucking. Thus, for example, as to the initial shape of bushes aimed at :—In one garden the manager prides himself in his bushes having stout erect stems, perhaps 2 feet above ground before branches are given off. In another special merit is claimed for the fact that the bushes have practically no stems, three or four main branches having been made to rise almost from the level of the ground in order to carry the leaf-bearing twigs. In a third the stem has been headed down to produce a pyramidal bush, the merit of which, we are told, is an immensely strong central axis. In still a fourth broom-like masses of erect shoots form dense clumps, produced it may be from three or four plants having been grown together or as a consequence of heavy pruning.

Size of Bush. *Conf. with para. 200.*

So again, according to the system of pruning, the bushes may be kept at a very large size, say 3 to 4 feet high and from 4 to 6 or even 8 in diameter, and clipped to a perfectly flat table-like surface. According to another the bushes are small, spreading and open, in consequence of being each year pruned down to little more than 18 inches or 2 feet above ground, also to their having all superfluous twigs carefully removed. According to a third the bushes are preserved in the pyramidal condition already mentioned, so that in winter the central naked stems stand up like the masts of ships in a crowded harbour. In still a fourth the central stem is headed back and the branches and twigs in the centre yearly thinned so that the bush assumes the so-called saucer shape, being low and open in the middle but high and dense on the circumference.

Yield to Acre Governing Principle.

177. Underlying these and such like diversities in both the initial shape desired and in the subsequent prunings, there is a fundamental bone of contention that may be expressed thus :—Distant planting with large bushes *versus* close planting with small bushes. But let me add that there no doubt are certain advantages of one system as compared with another, in relation to the class of plucking prescribed by the owners or agents. It would accordingly be unjustifiable were the assumption made that the diversities that exist are entirely a consequence of personal idiosyncrasy.

The examples mentioned are, however, but a few out of the numerous diversities met with all over the valley of Assam. Each, it may be added, is often hotly contested as being by far the most advantageous. Should even a suggestion of hesitation to accept that

view be offered, a reference is invariably made to the dividends that had been paid to the share-holders of the concern. It will be understood, therefore, that in the face of such odds it is naturally difficult to make progress in the advocacy of views that are apt to appear as purely theoretical. It is often and not unnaturally regarded as simple presumption for a person, not himself a practical planter, to assert that, better and more lasting results might be attained by a modification of systems that have been pursued with financial success close on half a century.

THEORY of PRUNING.

Financial Arguments.

XXVIII.—*Theory of Pruning.*

178. One of the ablest papers on the subject of the pruning of tea bushes was written by Dr. (now Sir) George King and published in the Agri.-Horticultural Society's Journal for 1871 (*Vol. III., Pt. 1*). It seems desirable to give here a few passages from that paper which, it is feared, is not sufficiently well known by the planting community. "Now the bearing of flowers and fruit," writes Sir George, "is the natural consummation of a plant's life, and the removal of these after they have been produced does no harm to the producing plant as an individual (on the contrary often benefits it), although the act affects its possible posterity. It is true that, in order to force it to bear unnatural quantities of flowers and fruit, or flowers and fruit possessing unnatural qualities, the horticulturalist often exposes a plant to treatment which is injurious to it as an individual, and which leads to premature old age; at the same time it is treatment, which, as regards flowers or fruit, is the most advantageous. In contrast to this is the action of the tea grower who, by the very collection of this crop, necessarily exposes his plants to treatment which, as regards a continuation of that crop, is disadvantageous."

Production of Flowers.

Leaf Crop Disadvantageous.

"In the cultivation of almost all kinds of fruit trees, the operation of pruning holds a prominent place. The problems respectively presented to the European grower of fruit and flowers, and to the Indian cultivator of tea being different, it is only reasonable to expect that different methods of practising that operation would be advisable. The general practice of pruning as carried on by European gardeners is, however, founded, for the most part, upon a knowledge of the principles of vegetable physiology, and it is, therefore, also reasonable to suppose that Indian tea growers might have learnt a good deal

European Experience. *Conf. with para. 175.*

Pruning.

THEORY of PRUNING.

on the general subject of pruning from European writers on gardening even although not venturing to put their plantations under the charge of practical European gardeners with full powers to do as they might deem best. Until within a year or two ago, however, the only kind of pruning attempted in the tea gardens of the North-West Provinces, was the removal of wood actually dead, and the application on rare occasions of a hedge clipping-scissors, which delicate implement used to be entrusted to a native gardener (*mali*) with orders to reduce by its means certain bushes to a particular height, a stick of the required length being given to him as a measure. Indiscriminating treatment like this is the kind of pruning to which a few gardens in these provinces used now and then to be submitted.* Rational pruning involves consideration and selection; and each bush ought to be treated according to its own individual condition, and not in accordance with a rule of thumb laid down for an entire field or garden. It is only certain stems and branches to which, as a rule, the knife can be applied with advantage, and these for the most part are the ones that afford the most marked examples of the natural effects of "plucking." Now, if we think of the matter for a little, the process of "plucking" will be seen to be really of the nature of pruning, and to recommend pruning as a cure for the evils of plucking, may, therefore, appear paradoxical. To explain the seeming paradox, let us consider briefly the appearances presented by a young shoot of tea before it has been deprived by the plucker of its tip with the three or four leaves or leaf-buds born thereon. Such a shoot bears on its entire length, let us say, ten leaves, and at the point where each leaf springs from the stem (*i.e.*, at the axil) there lies a small bud. Each of these buds is capable of development into a lateral branchlet. In a branch bearing as we have supposed ten leaves, it is not probable that, were things left to their natural course, each of the ten axillary buds would become developed into a natural branchlet. When, however, the growing point of the shoot is removed, these axillary buds are stimulated by the ascending sap, and most of them expand into lateral branchlets; and these being in turn topped by the plucker, their axillary buds are stimulated, though in a less degree, into expansion into branchlets, and so on. The vigour

Pruning to a fixed Height. *Conf. with paras. 96, 110, 298.*

Pruning Individual Necessities.

Plucking a Method of Pruning. *Conf. with para. 226.*

Formation of Shoots. *Conf. with paras. 197-8, 228, 246-7.*

* The practice is by no means unknown in Assam to the present day though the scissors is not used. [*G. Watt.*]

with which lateral branchlets follow on "plucking" or topping the leaders, diminishes regularly with each repetition of the process until after a few years of such treatment a period of nearly complete stagnation is reached, and the original ten-leaved shoot with which we started, presents the appearance of a tough greyish-barked and often gnarled stem, bearing at its top a dense collection of small wiry twigs, which carry a quantity of small thin tough leaves, totally unfitted for manufacture into good tea. These twigs, moreover, are of such low vitality that when topped they hardly respond by throwing out fresh lateral shoots or "flushes." This is the kind of stem of which the clumps of unpruned tea already described consist. The reason of the smallness and non-activity of the leaves upon these brush-like masses is simply that they have increased in number out of proportion to their means of nourishment. The stem, through the sap-wood layer of which their nourishment is transmitted, has not increased proportionally with the number of the leaves which have been forced into existence by the operation of plucking; and it is a physical impossibility that, through the layer of sap-wood in the stem, there *can* be transmitted enough sap to support many young leaves, in addition to old ones with which its top is crowned. Were such a stem left to itself, and all plucking suspended for a time, it is probable that in some cases an equilibrium would be established between the leaves and sapwood, and that the latter would again become extensive enough for the transmission of sap sufficient to suppotr a natural succession of young leaves, or, in other words, to "yield flushes." But the process of recovery would involve time, which to the tea-planter means money. A quicker way, therefore, of obtaining leaf must be tried, and this is found in pruning off the profitless wiry spray with which the stem is crowned, so that the sap transmitted upwards may cease to be dissipated away in the support of leaves which can never be made into tea, but which as long as they remain on the plant must have their needful supply of sap; and further, that the sap may be directed into the new shoots which the plant may be expected to throw out after pruning."

"It is thus that pruning becomes the necessary sequence of plucking, if healthy young leaves fit for tea-making are sought to be continuously produced. The end in view should never be lost sight of when using the knife, for the mere meaningless mutilation of a plant by its application is quite as likely to be hurtful as not."

THEORY of PRUNING.

Number of Leaves.

Low Vitality of Flush-bearing Twigs. *Conf. with para. 206.*

Weakened Stem.

Bushes Recover if not Plucked.

Dissipation of Sap.

Pruning Hurtful.

POSITION and ANGLE of SECTION.

XXIX.—Position and Angle of Section.

179. These are essentially the most important considerations in connection with pruning. I freely admit, however, there may be some difficulty in making the ordinary garden coolie an expert pruner. But, on the other hand, I cannot believe that there is no intermediate position between efficiency and culpable negligence. On several occasions when being taken over gardens I was given, with slight variations, the following apology for the wretched condition of the bushes:—"My predecessor, because of instructions from the owners to curtail expenditure, employed Nagas to prune the garden. These men contracted to cut the bushes down to a required height. And they did so by hacking them to pieces." There could be no mistake as to the existence of ruthless destruction and the explanation of the operators employed (if correct) was a natural enough one.

Naga Pruning.

Pruning to Individual Requirements. ***Conf. with para. 110.***

180. On the other hand, I was taken over many gardens where the bushes had been pruned according to their individual requirements. In one the trained overseers went through their respective portions of the garden and fastened a pole bearing a coloured string or small flag alongside of each bush that would require to be heavy pruned or pruned in some particular way. The manager then went over as much of the ground as possible, along with the respective overseer of each section, and examined a sufficient number of the flagged bushes to satisfy himself that the nature of the work to be accomplished was fully understood. Pruning according to individual requirements was thus prosecuted day by day, the flags being carried to new bushes as the work proceeded. The results were very satisfactory.

Special Training.

181. ***Light Pruning.***—But there is a serious error involved in the assumption that it is only in heavy pruning that skill is required. The bush is formed according to the intelligence displayed in light pruning. Heavy pruning to a large extent is the amputation of useless wood formed through ignorant light pruning. Light pruning is, in the majority of gardens, entrusted to the women and, if properly trained, they could no doubt very soon become expert enough for all practical purposes. But there is a most destructive system which I fear very largely prevails of allowing the women to grasp a handful of last year's shoots and to lop these off at a common point some 4 to 6 inches above previous prunings.

Pruning by Handfuls.

Pruning.

182. ***The Operation.***—Each individual twig must be pruned according to its own requirements. A twig on the circumference of the bush should be cut in such a way as to encourage outward growth. If towards the middle, to cause a vertical elongation. In the majority of cases these results will be accomplished by the selection of a bud upon the lower side of the twig, if outward growth be desired. The twig should be held firmly in the left hand and the knife in the right, the blade being inserted on the inside and at about a quarter of an inch above the level of the base of the bud. The cut should then be made upwards and outwards (*i.e.* towards the operator) and at an angle of about 45 degrees, so that the tip of the section may be only just above the level of the apex of the bud. With a bud on the upper side of a shoot, the cut should be made in the opposite direction, namely, away from the operator.

POSITION and ANGLE of SECTION.

Mode of Cutting.

183. ***Formation of Snags.***—The most important part of these directions, however, is the position and angle of the section. If the knife be inserted below the base of the bud and a long slanting section be made, the bud will be starved and thus produce a sickly shoot. If the section be made at a point, say ½ to 1 or 2 inches above the bud, the protruding portion will be starved and die accordingly. This is the condition known to the gardener as a "Snag." I feel satisfied that the evil effects of snags will be found in every garden in Assam. When in Spring the sap ascends to the shoots, an accumulation takes place at the point near the topmost bud. This swells in consequence, the bud then bursts into foliage, the leaves commence the process of assimilation and, had the section been properly made, the elaborated sap would have, in a comparatively short space of time, caused the bark to heal over the section and extend into the new shoot until the existence of a wound had practically disappeared. This result is most desirable for, as already explained, fully matured or dead wood obstructs the circulation of the sap and retards growth. Instead of healing over, when a snag has been left, the effort made causes the swelling to grow larger and larger around the base of the projecting useless and dead apex of the old twig. The snag, when it dies becomes attacked by white-ants or other vermin. It is thus decomposed so that instead of a united bark covering the wound made in pruning, a hole is formed that fills with water and sets up a decomposition that extends below the point of origin of the new shoot, upon which the

Snags. *Conf. with paras. 186, 193, 208, 226, 231.*

Swellings at Point of Section.

Assimilation.

Dead Wood Obstructions to Circulation. *Conf. with paras. 65, 183-5, 220, 222, 225.*

Action of White-ants.

POSITION and ANGLE of SECTION.

Heavy Pruning. *Conf. with paras. 211-2, 217, 225.*

Obstruction to Circulation of Sap.

year's (or it may be several years') flushing depends. This is no imaginary picture, it was found by me everywhere, worse no doubt in some gardens than in others, but present in all.

184. ***Starvation of the Stem.***—The formation of a snag may not be of very serious consequence in the year immediately preceding heavy pruning, but I have on my table as I write these words several stems selected to illustrate defective pruning. These show snags formed year after year, for the past ten or fifteen years, until gnarled rotten swellings, corresponding to each year's prunings, may be said to have slowly starved the plant. This fact hardly needs further illustration. The sap ascends freely within the sap-wood of the well-formed stem till it comes to a great swelling that corresponds to the position of the first pruning. Wandering round this it ultimately finds an escape, let it be supposed, to the right along a branch some 6 or 8 inches long. At the extremity of this it is a second time obstructed by a swelling which is due to a snag. We may next suppose that the current is thereby deflected to the left. It finds an escape, however, along a more or less sickly twig. Thus this way and that, the ascending sap is obstructed on every hand. Is it to be wondered at, therefore, that against such difficulties an insufficient supply is drawn to the growing parts of the plant? Instead of being vigorous, the flushing in each succeeding season gives distinct indications of declining activity.

Depreciation. *Conf. with paras. 128, 214, 271.*

But the full significance of retarded circulation of sap is only obtained by studying the course of the downward current. So far as is known, no portion of the ascending fluid can be utilized till it reaches the leaves to be there assimilated. While the process of assimilation is taking place, the pluckers visit the bush and the majority of the young shoots and leaves are removed. What remains of the assimilated fluid now begins to descend but, as it has to permeate backwards and forwards through all the woody portions, the knots of dead wood formed at the snags become, not deflecting influences, but positive obstructions. It is, therefore, only natural that the lower and older portions of the stem are literally starved and often manifest immense open scars corresponding to old snags. Such bushes might in fact be spoken of, as living at the top and rotten at the bottom to an extent beyond what words can portray. No person who has not seen a really bad tea garden can form any conception of the miserable conditions under

Assimilation. *Conf. with paras. 58-64, 117, 245, 268, 297.*

Rotten Stems. *Conf. with para. 214.*

which the tea plant will still continue to live and even give dividends to its owners. **SHAPE of the TEA BUSH.**

185. For such a state of affairs there is but one cure, collar pruning down to the level of the ground if not below it. Half measures are unsatisfactory. I am asked but why not cut down to, say, 9 or even 3 inches above ground. I shall revert to this subject later on, under the heading of Collar Pruning (*p. 121*), but let me here say (for the benefit of those interested in the preservation of a few inches of the stem in which they have taken so much pride), that it has been starved for the past ten or fifteen, it may be fifty years, and can never be anything like so valuable as new stems rising from the ground which in all probability may become possessed of fresh vigorous roots. **Preservation of Stem.**

XXX.—Shape of the Tea Bush.

186. In the wild state the indigenous plant has been described as a small tree 20 to 50 feet in height. In general shape it somewhat resembles a poplar in having a stem with three or four main branches formed low down, that ascend parallel to the trunk and become of nearly equal dimensions. All the secondary branches also tend to ascend and are long, straight, slender and form very few lateral shoots. The flowers occur profusely on the well-formed wood of the older secondary branches. The wild tea plant never forms a solid, erect, rigid stem with a dense dome of branches and leaves, such as it is frequently forced to do under cultivation. **Shape of Wild Tea.** *Conf. with para. 27.*

During the first two or three years of its existence the tea plant should be grown with the idea of forming the shape of bush it is desired to possess. The question of the subsequent prunings for flushings should, for the time being, be left out of consideration. If the formation of the bush be neglected until the annual prunings have been regularly commenced, it will then be impossible to effect any material changes without resorting to severe measures that would still further retard the yielding capacity. The most important stages, therefore, in the life of the tea plant are those of its first, second, and third years. If the prunings of these years be left to ignorant hands, and snags are formed, the plant will be unhealthy throughout its entire subsequent existence. Apart, therefore, from the shape of bush most desirable, or the age at which it is agreed the first pruning should be made, it is most important that the early prunings be **Shape Formed Early.** *Conf. with paras. 43, 227.* **First Prunings.**

SHAPE of the TEA BUSH.

performed almost entirely by the manager himself, or at all events under his personal supervision and by specially trained intelligent men. In other words, what I wish to urge amounts to this that it is more important the prunings of the first, second, and third years should be carefully and rationally performed than any subsequent prunings. It is the character of these prunings, more especially the absence of snags, that will determine the activity and longevity of the bush.

In fruit culture there are said to be three forms of bushes:—

(*a*) *Standard.*—In this instance all the lower lateral branches, up to a certain height, are carefully removed, and the central bud encouraged to elongate. When the desired height has been obtained the central shoot is "headed" or nipped off. Lateral branches are then encouraged to a certain extent so as to form the terminal crown of boughs desired.

(*b*) *Dwarf.*—In this condition the central shoot is headed back at an early stage and the shoots that form below are trained to become the skeleton of the bush.

Conf. with para. 225.

(*c*) *Pyramidal.*—Lateral growth is encouraged and the central shoot has its terminal buds nipped off at various periods so that a slow central elongation takes place. The main laterals are also shortened so as to cause them to branch. The central stem in the fully developed tree has a dwarfed appearance being abnormally thick below and suddenly tapered above.

Opinion often Held.

Tea planters very often seem to pursue a sort of combination of the principles of (*a*) and (*b*). The bushes are allowed to run up to a height of 5 or 6 feet, or whatever they may attain during the first two or three years after being transplanted. All that is done meantime is to cut off or pull off (by a sudden jerk) all the shoots close to the ground. It is urged that the object of this treatment is to form a long straight tap root and to mature good wood, on which subsequently the flushing shoots will have to be borne.

Tap Root.

187. ***Tap Root.***—But it may fairly well be asked,—Is the formation of a long straight tap root so very indispensable to future success? Certainly if the shape of bush desired be that defined as the "standard," it might be admitted that, as a matter of simple mechanics, a straight tap root, to a corresponding extent below ground to the stem

above, would be not only desirable but even essential. There is no doubt on this point that if the stem be allowed to run up in the manner indicated, the roots will, in the majority of cases, become an exact counterpart of the stem. **SHAPE of the TEA BUSH.**

188. The roots of a plant are intended to serve a two-fold purpose (*a*) to procure soil nourishment, and (*b*) to fix the plant. The shape and character of the roots must, therefore, bear a direct correspondence to the stem and its branches, which they have to support. If tall, straight and unbranched, the swaying of such a stem in the wind must be provided for by deep roots. A great lateral spread would dangerously resist the natural swaying of the stem, while conversely a long straight deep root with few branches would be but ill-calculated to support the rigid condition of a short stem, carrying a dense head of many branches. Moreover, the crown of branches and leaves are intended to carry the rain-water to the soil right above the position of the young absorbent roots. A perpendicular root requires, therefore, a similar stem and with the branches ascending so that the rain may fall on the ground very closely around the trunk and not be carried to a distance. At the same time the peculiarities of the stem and the tendencies of the root are largely dependent on the nature and depth of the soil. Pine trees inhabiting rocky and precipitous mountains, make up for the want of depth of soil by an immense lateral spread of root and a correspondingly flattened crown of branches. It follows that if the tea land be either shallow, or water-logged at a certain depth, there may be little gained by causing the roots to penetrate to what may be practically viewed as the utmost limits of food supply. Moreover, by the production of only one root, the risk of the death of the plant through an accident to that root, is infinitely greater than should the plant possess a number of roots each fairly able to take on itself the chief necessities of the plant. **Roots.** **Branches Correspond to Roots.**

189. ***Unpruned Seedlings.***—But turning now to the examination of the elegant and vigorous seedling (three years old and 6 feet high) can it be said *it* has gained any advantage in the direction of the planter's ulterior object? It has undoubtedly been allowed to run up in precisely the way it would do, if growing in its wild habitat, namely, a tall delicate stem with a few erect or more or less ascending lateral branches. But when the check is given by the pruner's knife, it is now commanded to make up in lateral growth what it has lost in the **Seedlings.** *Conf. with paras. 97, 186.*

SHAPE of the TEA BUSH.

Age for Pruning.

vain, though natural effort, to form a vertical stem. The tall tea seedling practically contains neither branch nor bud that is not possessed by its less vigorous sapling of corresponding age. The difference is in degree of elongation, not in structural formation. The whole question is, therefore, one of the age at which it is most advantageous to the planter, to give the first check to the natural tendencies of the plant. Check those tendencies he must and check them year after year, for the knife alone can force a tree to go on growing (or flushing) long past the time it should be flowering and fruiting.

Flushing Power. *Conf. with paras. 178, 206, 220.*

Wood.

190. ***Formation of Wood.***—But the oft repeated statement made by the planter that he allows the seedling to run up to 6 feet or more before pruning, with the double object of obtaining both a strong vigorous tap root and a well-formed stem, must again be reverted to. It is necessary to dispose briefly of the question of advantage through the possession of a short thick stump of stem. And this may be done by the remainder that it has already been shown that the tendency to form wood is one of the most dangerous of all that has to be guarded against in tea cultivation. It might in fact be affirmed that the formation of stem to the cultivator who aims at leaf production is a necessary evil. It should be allowed to the extent absolutely required, but no further.

Extent to which Desired.

191. ***Check to Seedling Growth.***—It may now be desirable to compare two seedlings each three years old, the one treated by the system where the first check to its natural growth had been given at some period before it was 18 months old, the other when double that age. To begin with it may be put as a universal experience that the younger the plant the less severe will the shock be of first pruning. But, for argument's sake, let it be supposed that in both instances (early and late) the seedlings have been pruned at 9 inches above ground. It goes without saying that the 9 inches of the three years' seedling will correspond to a very much shorter portion of the other plant. Elongation must have taken place during these three years, for it is only after mature wood has been formed that it can be said growth in the lower portion of the stem of a tree is entirely horizontal and in no way vertical.

Age at which to Prune Seedlings. *Conf. with paras. 186, 189, 199, 205, 210-1, 225, 244.*

192. In my opinion, therefore, the first pruning should under no circumstance be deferred beyond 18 months from date of germination. I should in fact strongly recommend that it be made at a very much

Pruning.

earlier date, so as to ensure that the stunted stem thereby produced may contain in, say 9 inches, all the buds of a much greater elongation of the three years' seedling. In fact I should strongly urge the first pruning to be invariably accomplished in the nursery and, say, three or four months prior to the date fixed for transplanting. I should not, however, transplant any seedling that had not shown, by the production of lateral shoots, that it had recovered from the shock of pruning. If it be preferred to prune after transplantation the sooner the better, after the seedling has taken root. Let it be recollected in support of these views that snags upon thin non-woody shoots are, comparatively speaking, harmless.

SHAPE of the TEA BUSH.

Pruning in Nursery.

193. The shock to the stem of being pruned down to 9, 12, or 18 inches, from 6 feet, is practically as severe as a collar-pruning. The risk of a snag of a most damaging nature is, moreover, extremely great. When the buds are visible, a snag may be said to be the result of ignorance or carelessness. When a clean woody stem, perhaps 1½ to 2 inches in diameter or even more, has been allowed to form, the lateral buds may be said to be invisible, and it is consequently just as likely that the section may be made at the wrong as at the right place. Further, let it be remembered most of the lower buds have been purposely killed, in the production of the seedling 6 feet in height, so that the subsequent growth becomes largely dependent on nature putting forth accessory shoots, around the margin of the section. When this takes place, a dense crown of branches comes into existence, on the apex of a short abnormally thickened stem—a stem that preserves its predominance throughout the life of the plant.

Snags on Seedlings.

Adventitious Budding. *Conf. with paras. 234, 272.*

194. On the other hand, by the lower lateral shoots being encouraged and carefully pruned, so as to produce further branches, and the terminal bud headed backwards, during the first year or so of the life of the seedling, a dwarfed and much-branched stem results which, in my opinion, is greatly preferable for the purpose desired. It is not uncommon in gardens where the formation of strong wood has been encouraged, to find (according to age) a main stem 1 to 3 feet in height and anything between 4 inches and 9 inches in diameter. If it be recollected that the sap necessary to form and support that amount of wood might have produced and nourished, say, half a dozen branches, the full force of my contention will be realized. It is not the stem

Encouragement of Lateral Branches.

Useless Wood.

SHAPE of the TEA BUSH.

that bears flushing shoots nor even the skeleton of main branches on the top of that stem, but the young twigs a year or two old. The stem and its branches are but the supports and the channels through which the sap is passed on from the roots to the flushing shoots. That transmission can be accomplished just as well, if not better, without, as with, a stem, and its absence is, therefore, a distinct economy. An early division of the channel through which the sap has to flow secures, in fact, a more perfect and complete distribution. Moreover, when one after the other of the main branches, begin to give indications that systematic plucking and pruning have sapped them of their power of further effort, they may, if thought proper, be lopped off, one after the other, and new life given thereby to the flushing power of the bush by fresh branches.

Object of Branches.

195. ***Dwarfed* versus *Standard Bushes.***—My contention accordingly amounts to this that, although plants at three years of age, that have received their first pruning when 9 months old, may look puny, as compared with vigorous three-year old unpruned seedlings, they are for the purpose desired infinitely preferable. Let the two systems (first pruning at 9 months and first pruning at 2 to 3 years) be compared in the fifth or sixth year of the plants, and I venture to affirm the comparison will be greatly in favour of the early rather than the late system. The full value of the one as compared with the other will, each subsequent year, become more and more apparent as the time approaches for heavy pruning. With regard to the comparative health of the two plants there can hardly be room for two opinions. The strong central stem (as it has been designated) will then be seen to be a positive source of danger and loss, for heavy pruning will be a much more severe operation and resolve itself practically, though not admittedly, into an effort to produce the condition of bush that might easily have been secured from the beginning.

Advantage of Dwarfed Bush.
Conf. with para. 225.

Lateral Roots.

196. ***Lateral Roots.***—But if the object of the cultivation of the tea plant be the production of the greatest number of branches to carry flushing shoots, wherein comes the merit of the strong deeply set tap root? Let the stem, so much admired by the advocates of that system, be examined and it will be found to be eccentric, that is to say, grown on this side and that, instead of uniformly expanded. Why? because the tap root having been found unsuited to the peculiar demands laid on the plant, an urgent necessity may be said to have arisen for the

production of lateral roots to take the place of the now useless tap root. This statement may be readily demonstrated. **SHAPE of the TEA BUSH.**

Clear away the earth from around the stem and it will be found that each lateral expansion from the true centre, corresponds with a large lateral root. Follow this down still further and it will be seen that two or three such lateral roots have become larger and stronger than the original tap root. Dig the bush up altogether and it may be witnessed that these lateral roots have dwarfed and even strangled the original tap root. **Tap Root Strangled.** Cut the stem through and in the majority of cases it will be next found that it is hollow and possibly rotten in the centre. At three years of age the wood had not been matured, yet shortly thereafter new branches were produced and demanded so large a portion of the sap supplied by the roots, that eccentric growth ensued and the original stem may figuratively be said to have been first imprisoned and then starved. With this state of affairs I should like to challenge comparison with a plant, the stem of which may be seen to have broken into three or four branches of equal size a few inches above ground. **Dwarfed Bushes Healthier.** There will be found no eccentric growth, no strangulation of the roots, no decomposition of the heart-wood. It is, therefore, in a healthier state.

197. ***Change Essential.***—The tea-planter has thus to change completely the natural habit of the plant. There is no use of closing the eyes to that fact. The sooner, therefore, that the plant is made to assume the condition most suited to the arbitrary demands of the cultivator, the better for its future life. It is in my opinion both an unnecessary delay and a hurtful proceeding to indulge the natural proclivities of the plant for two or three years and then suddenly force it to assume a condition altogether unnatural.

Reasons for Change of Form.

Conf. with paras. 26, 30, 45, 51, 92, 106, 166, 315, 318, 320.

It has of course been taken for granted that tea could not be manufactured at all, were the plant allowed to grow in its natural condition. Ladders would be required by the women in collecting the young leaves. Moreover, the bushes would produce only one flush a year—the spring growth—and would expend the remainder of their annual energies in flowering and fruiting. The simple act of plucking shoots is unnatural, because the plant is thereby compelled to make a second effort to produce its year's growth. These new flushes accordingly originate, not on last year's fully matured twigs, **Origin of Flushing.** but on this year's immature shoots, which were perhaps only a few

SHAPE of the TEA BUSH. weeks old. If again the second flushings are removed, a further effort would no doubt be made, but upon still more immature shoots, and so on it would go until at the end of the season pruning would be as essential to secure flushing on the wild as on the cultivated plant. It is, as Sir George King puts it, paradoxical, but true that to ensure plucking you must prune systematically. The act of annual pruning of necessity changes the nature of the plant, and it is, therefore, beside the point (even were it correct) to say that the one system is superior to the other, because of its being in accordance with the natural habits of the plant. A seedling is better able to adapt itself to the arbitrary conditions to which it has to be exposed than a plant of mature years.

Change Unavoidable.

Adaptation to Chinese Cultivation. 198. The Chinese have cultivated the tea plant for centuries no doubt, as compared with the half-century of Assam cultivation. Their results show what can be, and is likely to be, attained by adaptation to the tea-planter's demands. The one feature of the original form of the plant that still remains more or less true of the Chinese stock, is the tendency to produce ascending instead of spreading branches. But I have no doubt the great central tap root has practically disappeared. I have not had a sufficient number of Chinese plants dug up and examined to justify a definite statement regarding the conditions of the root in that plant as compared with the Assam indigenous, but I am satisfied on one point, that it shows a pronounced tendency to multiplicity of roots. It no doubt also is largely on this account that the hybrid stock is better suited to hilly regions, or localities with a shallow soil, than the pure Assam. Like its China ancestor it produces a larger number of short roots than is the case with the Assam indigenous. So again even the Assam indigenous, once removed, has less vigorous roots than stock raised direct from indigenous seed. These are points which I took some trouble to enquire into during my Assam tour. It would be contrary, however, to all experience to suppose that a plant could be grown for generations under a system of constant pruning and still preserve the great central tap root characteristic of the tall practically unbranched stem of its wild state.

Condition of Roots in Hybrids.

Branched Bush Recommended. 199. ***Opinions of Authors on Best Shape of Bush.***—But I must hasten to bring these remarks regarding the most desirable shape of the bush to a close. It need hardly be repeated that I am strongly

Pruning.

in favour of stunted bushes, branched from near the ground. But I am fully aware that I thereby advocate a shape of bush very different from that recommended by most writers on the subject. **Mr. Shipp** says, "Strip off to 8 inches above ground, by breaking or cutting them, all the small lower branches." **Mr. W. C. Muller** says, "Let there be fully 10 inches between the surface of the earth and your lowest branches." **Mr. J. F. W. Watson** goes into great detail as to the difference between the advocates of light and of heavy pruning. He proposes that the seedlings should be left alone for the first two years, then pruned down to 3 feet, and in the third year 2 or 3 inches lower still. He then adds, "A plant thus treated has to begin with a stout, strong stem, and the pruning adopted leaves it ample room for side development and it is only at the sides that real development is possible." Briefly this may be said to be the pyramidal system which I have already condemned.

SHAPE of the TEA BUSH.

Pyramidal Bushes.

Conf. with paras. 176, 186.

Mr. T. G. Stoker says, "Unnecessary length of wood is a source of danger, not of strength." "The plants should be as large as possible, but their size must consist in their number of strong cleanly grown, well-placed branches, and in the length of old hard wood." A Cachar planter whose confidential report to the Agents of his Company has been kindly shown to me, says, "An indigenous plant ought never to be touched, or have its growth checked in any way, till the end of the third year when it should receive its first pruning by being cut back to a height of 36 inches." **Mr. S. Baildon** remarks that, "Inadequate pruning" is a "cause of inferior tea." **Mr. Bamber** writes, "The main question to be solved as regards the pruning of the plants, in their young stage, is, what method should be adopted to produce the most satisfactory form of bush for yielding purposes? The formation of good straight wood in the stem or stems would be the first consideration; on a good free soil, and with plants raised from sound seed, pruning would be unnecessary, until the required thickness at the base of the stem had been obtained, for the plants would grow in a perfectly symmetrical manner, the wood increasing in diameter as it gained in length; but on a poor soil unsuitable for tea from want of drainage, etc., or with plants raised from seed of indifferent quality, the growth would be slow and unhealthy, resulting in the formation of a hard and bark-bound stem, which would have to be cut away and the other defects remedied before healthy growth

Indigenous Seedlings Pruned at Three Years.

Formation of Wood said to be first Consideration.

Unhealthy Seedlings

Pruning.

SHAPE of the TEA BUSH.

could result." I am sorry to say I can neither follow Mr. Bamber in this line of reasoning, nor agree with him in his recommendations. In the case of the unfortunate plants on bad soil I should say the natural course would be to improve the adverse conditions before attempting the cultivation of the plants at all. It is difficult to see why the badly fed seedlings should be still further punished by being pruned, until the time had arrived for their being sufficiently well nourished to be able to produce the good wood which Mr. Bamber seems to regard as indispensable.

One Large Bush *versus* Two Small Ones.

Conf. with paras. 87, 176.

200. In the foregoing remarks I have reasoned mainly, however, from the standpoint of the health of the bush and cannot support my conclusions by actual statistical returns. No doubt a garden of large bushes looks as if it might be very productive, but the majority of planters, whose views I obtained on this point, were distinctly in favour of low well-formed spreading bushes. I should think in fact the opinion of the majority would be that, two bushes, each 2½ feet in diameter, would give a better return than one bush of 5 feet in diameter. And when it is recollected that two sets of roots are brought to bear on the plot of soil, it can hardly be conceived that the roots of one bush, however perfect, could be anything like so efficient. Moreover, the liability to injury and blight is very much greater, one might say practically doubled, by the one large, as compared with the two small, bushes. Both would have to be killed to equal the loss of the large bush. Now it goes without saying that pests and blights (all other conditions being equal), are more serious in overcrowded gardens than in those with liberal spacing, and similarly pests and blights are more dangerous in the heart of an unwieldy bush than in a small one, since the latter can be examined and cleaned out while the former may be regarded as inaccessible. To these arguments I need hardly add the waste of flushing power in the nourishment of a useless amount of wood.

XXXI.—Season of Annual Pruning.

Needless Exposure of Wood.

Conf. with paras. 219-220.

201. There may be said to be a concensus of opinion in favour of the annual pruning being delayed as long as the strength of the labour staff will admit. Some few writers have said, however, that pruning should be commenced immediately after the sap has ceased to ascend. This I venture to affirm is a mistake. What object could there be in needlessly exposing the cut surfaces of the branches and twigs to the

drying influences of the atmosphere? Absolutely no effort will be made by the plant to cover the wounds, till the sap begins in Spring to carry up the food supplies. This early ascending sap, however, has to be assimilated by the old leaves on the bush and be sent by these to the cut surfaces. This fact shows how very ill-advised the system is (sometimes followed I understand), to direct the pruners to pluck off all the old leaves from the bushes. This should on no account be done, since assimilation will thereby have to be accomplished by the barks of the few young twigs still left, and the bursting forth of the new shoots will accordingly be greatly retarded. If it be desired to remove the old leaves, this had best be done after the shoots have appeared, certainly never before.

SEASON of ANNUAL PRUNING.

Stripping Leaves.

The actual date of commencing pruning should not, if possible, be much before the middle of December and the work should be completed by the middle of February. In Assam the sap may be said to commence to ascend in an average year, about the 15th of February.

Sap Ascent. *Conf. with paras. 61, 183.*

202. ***Character of Pruning.***—If the *first* pruning be given in the nursery, this should practically consist in heading the seedling down to, say, 12 inches or, if it is only about that height, in nipping out the central bud. This will not only strengthen any side shoots that may exist, but cause other lateral buds to commence to grow. At the same time it will check the too great development of the tap root and encourage the formation of lateral roots. With seed at stake the first pruning should be similar to that recommended for the nursery and be performed about the 9th or at latest the 12th month after germination.

Seedlings First Pruning.

Check Formation of Tap Root.

203. The *second* pruning should consist of still further heading back the main stem and training all the lower shoots. Small and useless branches resting on the ground should be removed, but never torn off as some writers recommend. The branches low down, which it is desired to retain, should be shortened to the fourth bud (to be found, as a rule, on the lower side of the twig): the next higher twigs should be shortened to the third bud, and those near the top of the seedling to the second bud. Trimming in this manner will produce lateral growth and thus open the bush up.

Second Pruning.

Shortening the Laterals.

204. The *third* year's pruning should consist in finally heading back any tendency that may still exist toward the formation of a main stem and in removing branches that might be calculated to produce

Third Pruning.

Pruning.

SEASON of ANNUAL PRUNING.

an overcrowded condition. But the lateral branches once trimmed in the second year must not be interfered with during the third. Every encouragement should be given for their being elongated and strengthened to the utmost extent possible.

Early Pruning of Seedlings. *Conf. with paras. 186, 189, 199, 210-11.*

205. But I hear some of my planter friends exclaim, this would be all very well for a fruit garden but not possible with a large under-manned tea estate, owned by persons who expect returns even in the third year. My answer is that I write purely and simply as an advocate for measures being taken to preserve the health of the plant and consequently cannot even admit opposing financial (should I not rather call them short-sighted and selfish) considerations. I am told that I advocate a system once adopted, but in the majority of cases long since abandoned. I am fully aware of that fact. Mr. J. F. W. Watson *(Prize Essay, 1872)* for example says, " I consider that those thorough-going low pruners who believe that they cannot too soon commence with the adaptation of that principle to the plant, and therefore begin by systematically nipping the seedlings of the first year are quite as much in error, although there is not the fear as yet of fatal consequences. This plan is to tip or nip the seedling of one foot high to make a bush of it from the first. And accordingly a bush is made of it, and the plant by the shooting forth of numerous little branches is at the end of eighteen months about half the height, it would have naturally attained."

Results.

Quite so, but when the unpruned seedling of three years old, has been cut down to 9 inches it is then in a much more backward state than the little bush spoken of so contemptuously. The pruned down stem has to begin life anew, burdened with a useless amount of wood and an equally useless tap root. Mr. Watson and his followers have had 20 years to give effect to their plan, and I think the result points clearly to some radical change as imperatively necessary.

Trained Nurserymen.

Let me add, therefore, that the treatment of the seedling should be a matter entrusted to a special staff trained for that purpose. Everything should be done to secure a healthy condition regardless of all other considerations.

XXXII.—Requirements of Flushing.

Flushing Power of Plants. *Conf. with paras. 178, 229.*

206. The principle of flushing may be said to be that there has been brought into existence a bush the stems and roots of which are capable of producing and nourishing (to figuratively express it say)

100, young shoots. The pruner comes and lops off a large portion of the parts above ground. The roots are thus in excess of the necessities of the existing stem and its branches, and, instead of 100, the roots cause the production of 200 shoots. These are the flushes, but observe if care be not taken in the first three years to develop a bush capable of meeting every possible future necessity, that result cannot be attained. If the roots be imperfectly formed, that is not sufficient in number or not properly placed to discover the food, the stem and its branches cannot be expected to force on repeated flushings. The bush becomes *banjhi* (*i.e.* barren) a condition well known to the planter in which flushing may be said to have come prematurely to an end.

REQUIREMENTS of FLUSHING.

Banjhi Buds. *Conf. with paras. 50, 79.*

207. There could be nothing more short-sighted, therefore, than to grudge the time and expense necessary to form the bushes carefully, during the first three years of their existence. It is positively suicidal to pluck bushes before their fourth year. When plucking and pruning have been established all idea of forming the bush may be regarded as practically at an end. The subsequent life of the plant is a constant struggle for existence and its powers of endurance will depend entirely upon the treatment it received during the first three years.

Seedlings Plucked in their Third Year.

XXXIII.—Nature and Extent of Annual Pruning.

208. I do not feel called upon to lay down any arbitrary rules as to the extent of pruning to be annually given, to a properly matured bush. I protest, however, in the strongest possible terms against the vicious system of sending out coolies with a measured stick and orders to cut all down to that height.* There can be nothing more dangerous than indiscriminate use of the knife. Mr. W. C. Muller (*Prize Essay, 1865*) very truly remarks, "Do not prune too heavily, nature must be aided, not overstrained." Pruning is required to cause repeated flushings and, as a rule, the following should be removed :—

Parts to be Pruned.

(*a*) All dead branches.

(*b*) All gnarled twigs and crow's-foot clumps of imperfectly formed shoots—last year's flushings.

(*c*) All snags seen to have little chance of healing over. The longer removal is delayed the worse for the bush.

(*d*) Any branch or branches that would tend to disturb symmetry.

* I am told it is an unfortunate necessity: sickly bushes are over-pruned and killed no doubt, but in time uniformity in growth is secured so that a fixed system of pruning becomes possible. (*Conf. with page 100.*)

Pruning.

NATURE and EXTENT of ANNUAL PRUNING.

Pruning up.

209. Many planters prune up, as it is called, for a number of years then down suddenly and again slowly work up, and so on. I took numerous notes from conversations with planters on this subject, but do not think it necessary to analyse the various views advanced. So long as the general principles of pruning are observed (once the bush has been properly formed) there is very little that need be criticised of the systems that prevail except to avoid forming snags. I shall give, however, as characteristic of the most generally accepted methods, the following:—

The Most General System.

210. At Patalipam, North Lakhimpur, on the 9th of July I discussed with Mr. J. Lindsay Alexander, the sytem of pruning. His first remark was to the effect that for the light sandy soil of these gardens it had been found desirable to encourage a strong tap root—with the object of preventing the bushes being uprooted by wind and heavy rain. Mr. Alexander continued, "When they are three years old, I cut the bushes down to 8 inches, and this is done about January. I would rather prune a little later. The annual season for pruning should be as near as possible to the period when vigorous sap ascends."

Late Pruning for Transplanted Seedlings.

"Tea treated in the manner indicated would be left for a further year (if of good *jat*) and then pruned down to 10 inches above the original or first pruning. I always prune down, then work up till the plants become too knotty or too high, then prune down to 6 inches above first pruning (that is 4 inches below the second pruning) and I collar prune as may be necessary for individual plants about nine or ten up to fifteen years from date of transplanting."

Early Pruning for Seed-at-stake.

"In some cases I have adopted a different plan; owing to the difficulty of keeping the soil attached to the roots of seedlings, when transplanting, I frequently sow seed-at-stake. This is done from January to March and these seedlings are plucked for tea about August, when they are only 10 inches high. The plucking is, however, made in order to check the upward growth. This system has been followed with the very best results, the plants throw out 3-4 branches from near the ground."

211. In my opinion it is a mistake to delay the first pruning till the seedlling is three years old. Mr. Alexander's recommendation turns on the statement that a useful tap-root is produced. But how comes that to be unnecessary with seed-at-stake in the same soil?

The growth of the tap-root is very possibly arrested by the heading back of the stem. Indeed I question the advantage claimed, unless very rarely when the food supplying stratum is deep seated.

NATURE and EXTENT of ANNUAL PRUNING.

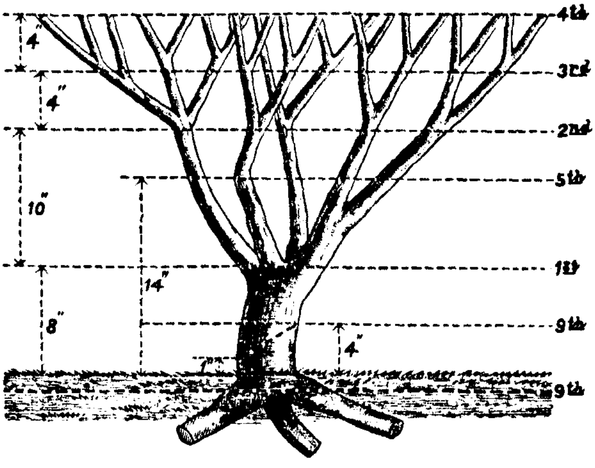

FIG. 1.

REPRESENTATION OF FIRST TO NINTH PRUNINGS.

Mr. Alexander's system may be illustrated by the above engraving. The dotted horizontal lines indicate the positions of the various prunings, and the vertical lines, the approximate heights above ground. When three years old the plant was cut down to 8 inches. Four main branches were then produced with corresponding roots and in all probability the death of the tap-root. The second pruning was done at 18 inches when each of the main branches sub-divided. The third, 4 inches higher and the fourth, 4 inches still higher. The fifth is supposed to be carried down to 14 inches from the ground. The sixth, seventh and eighth are light prunings, corresponding to the third and fourth. The ninth should, in Mr. Alexander's opinion, be on the main stem and about 4 inches above ground ; I should prefer it to be carried *just below ground*, as shown in the engraving.

Buds of Spring Shoots.

Conf. with Fig. 9.

Between the second and third, and between the third and fourth prunings, well-formed red shoots, each bearing at least two buds, had been retained. These are light prunings of this system. Heavy

Pruning.

NATURE and EXTENT of ANNUAL PRUNING.

Heavy Pruning.

Second Collar Pruning. *Conf. with para. 225.*

Productive Age.

pruning would be the fifth and should be accomplished according to individual circumstances when the bushes are from six to eight years old, never later. Mr. Alexander does not approve of a second heavy pruning between the points of the fifth and the first, nor below the level of the first prunings, but would prefer in all cases to collar prune. In his opinion the process indicated may be repeated in all its details by collar pruning and in some cases collar pruning may even be performed a second time, but by 30 or at most 40 years the bushes become so depreciated that new plants are distinctly desirable to any further effort toward renovation of the old stock. But in Mr. Alexander's opinion no hard-and-fast rule can be laid down, and, speaking generally, he thinks the time to collar prune is when the plant ceases to produce strong succulent shoots.

Age of Branches on Late Pruned Seedlings. *Conf. with para. 227.*

It will be seen that Mr. Alexander's first pruning, on transplanted seedlings (performed when the bush was three years old), is the only one that could be said to have been accomplished with the express object of forming the bush. A stem that may have been 6 feet high and 2 inches in diameter near the ground, was thus cut down to 8 inches. As a result (according to my rough sketch, Fig. 1) four shoots appeared around the section, one of which subsequently divided by the growth of a lateral bud. In the fourth year the bush had, therefore, five flush-bearing branches. These were plucked throughout the year until each came to carry a small broom of twigs. But observe they were plucked when less than one year old. At the second pruning the crow's-foot clumps caused by flushing were cut off and thus each of the main branches came to bear two, three, or four Spring shoots. At the third pruning these twigs were cut back to lengths each carrying two buds.

Number of Light Prunings.

212. Some planters take a fifth and even a sixth years' flushings in continuation of the third and fourth, before resorting to the heavy pruning shown in the diagram as the fifth. And they even profess to be able to repeat all the details given by not one heavy pruning only, but two or three, before they admit that the necessity has arisen for collar pruning and some planters even deny that necessity. But what is still more surprising, by the large table-bush system (to which I have alluded) the light prunings (three and four) are continued indefinitely. The main branches, formed for the most part on the apex of a solitary erect stem, are looked upon as inexhaustible, they

Shaving off Flushings. *Conf. with paras. 267, 272.*

are regarded as the soil to a lawn that can be mown down of all its flushings from year to year, with nothing further being done than to nip off dead wood and thin out when overcrowding occurs.

NATURE and EXTENT of ANNUAL PRUNING.

213. ***Disposal of Prunings***—Under Section XXVI, pages 94-96, will be found a brief account of this subject. It need only be said here that they should invariably be burned, never trenched into the ground.

Starvation of Stem. *Conf. with para. 184.*

214. ***Conclusion,***—It need hardly be repeated that I think the idea should be kept clearly in mind that successful flushing involves the starvation of the stem. That old, or prematurely old, wood is liable to disease, has a constant tendency to flowering, and obstructs a free circulation of sap. Apart, therefore, from a decrease in flushing power with age there must also be a steady decline in *quality*. I do not recollect a garden that adopts the large flat table-bush system, obtaining high prices though many no doubt have hitherto given excellent returns to their owners. It can be easily understood that as long as a fairly large percentage of gardens aim at returns from quality, profits may and no doubt can be made on *quantity*. By delaying the period of plucking so as to give strength to the shoots, weight in outturn can be secured as also greater longevity to the bush. These are, however, opinions that I only mention as having a bearing on the question of the health of the plant. To conclude, therefore, I am abundantly satisfied that a very large percentage of the diseases and pests of the tea plant are a direct consequence of age, or premature age, as it might more correctly be called.

Depreciation. *Conf. with paras. 128, 271-5.*

Liability to Blights with Age.

But this leads me now to consider the subject of collar pruning which has of late years been recognized as vastly important and it deserves accordingly very special consideration :—

COLLAR PRUNING.

COLLAR PRUNING. *Conf. with paras. 38, 185, 193, 211, 272.*

XXXIV.—The Collar or Union of Root to Stem.

The Collar.

215. Theoretically the collar of a plant is the imaginary point of union between the root and stem. If the skin be pealed off a pea or bean it will be found that the contents divide into two large portions and that the halves may be seen to be hinged together by the embraced embryo. The two fat structures are the first leaves of the infant plant, greatly swollen by being made the store houses of the food required for germination. The point of union of these seed leaves to

The Embryo.

POSITION of the COLLAR. the embryonic axis is the true collar; the lower extremity of that axis becomes the root and the upper the stem. The most marked difference between the root and the stem lies, however, in the fact that the former (as already fully explained), has assigned to it the function of absorbing food from the soil. But it is commonly stated there is another difference, namely, that the root has no buds and cannot, therefore, be used as cuttings in the propagation of the species. Rootlike structures, possessed of buds (such as the eyes of the potatoe), are pronounced to be underground stems, not roots. The distinction here indicated is so true of the vast majority of plants, however, that when roots are found capable of independent growth they are at once assumed to be underground stems and not roots.

The Root.

Underground Stems.

216. The fear entertained, by many planters, against collar pruning is that they run the risk of cutting below the collar, as defined botanically, and thus of killing the plant. The answer may be given that a good many plants would seem to produce, below the actual collar (or point of origin of the seed-leaves), structures that we must define as roots but which, nevertheless, can and do bear buds. The tea plant possesses this exceptional property. Let a bush found growing on root stilts, owing to the surface soil having been washed away, be severed, so that the separate roots remain projecting out of the ground, and I venture to think a good few will shortly thereafter be seen to throw out shoots. On the faces of roadway cuttings, roots, often 3 feet below the level of the soil, may not infrequently be seen to bear shoots. From these and such like examples, it may fairly be inferred that the risk of cutting below the theoretical collar, is a remote contingency. Moreover, in transplanting, seedlings are invariably placed in their new positions with a considerable portion of the stem below ground.

Root Budding.

XXXV.—Imperfect Collar Pruning.

High Collar Pruning. *Conf. with para. 225.*

217. ***High Collar Pruning.***—The term collar pruning, as I found it employed in Assam (with one exception), was applied to all instances where the entire bush was cut away, so as to leave a stump of the original stem that might be from 1 to 9 or even 12 inches above ground. The distinction between the latter and the condition designated "heavy pruning" was simply in the fact of only one instead of several stumps remaining. Collar pruning was thus through the common stem instead of across its main branches, irrespective of

position in relation to the ground or rather the roots. For both heavy and collar pruning the saw is invariably required.

IMPERFECT COLLAR PRUNING.

Slanting Sections. *Conf. with para 225.*

218. The advantage of sections through strong wood, being made in a slanting direction, and on the lee side of the stem (to the point of greatest rainfall), I found fully recognised in Assam and all but universally followed. The bark on its commencing to grow forms a rim around the exposed section of wood, which must of necessity become a saucer or shallow depression to retain water, that would prove injurious, were the section made on the level.

219. From the remarks already offered on the necessity of checking the formation of wood, it goes without saying that I am a strong advocate for collar pruning. But, on the other hand, I desire to make it clearly understood that I regard the half-hearted manner in which collar pruning is accomplished by many planters, as one of the greatest and most serious blights that has overtaken the industry. To ruthlessly saw off the head of a bush and leave exposed to the atmosphere a stump of wood that may be from 2 to 6 inches in diameter and 4 to 12 inches above ground, is to produce a snag of a kind fatal to the future life of a very large number of the plants operated on.

Danger of Collar Pruning.

220. ***Bushes on Rotten Stumps.***—By way of illustration we shall suppose collar pruning has been made in November *—a very early date. In passing it may, however, be remarked that Mr. Bamber defends early (heavy) pruning as follows:—"It is generally acknowledged that plants, although apparently dormant through the cold season, are slowly accumulating plant food from the soil, and storing it up in their stems and branches; by early pruning, therefore, none of this reserve material is removed from the plant." If the sap circulation has stopped it is difficult to see how this storage could be accomplished, but even admitting there may be some grounds for the opinion, the reasons opposed to early pruning in my opinion far outweigh all other considerations.

Early Heavy Pruning. *Conf. with para. 201.*

Justification of.

By early pruning the stumps are exposed to the atmosphere for at least three, and in backward years four months, before any upward current of sap takes place. By that time the exposed wood has in all

Needless Exposure of Wood.

* A planter of great experience writes me that in his Company they prefer to collar prune in November. But I should like to ask have comparative experiments been performed with early and late collar pruning to test both the rapidity of restoration and quality of new bush obtained? I believe the bushes from late pruning will be healthier than from early.

IMPERFECT COLLAR PRUNING.

Risk of White-ants.

probability been killed and perhaps attacked by white-ants, or, if not it stands a great chance of being so attacked during the approaching rains. Let it be supposed that the plant operated on was a vigorous one. Shoots no doubt would appear in March or April, but if it happened to be sickly, the shoots might not come till next Spring or the plant might even be killed entirely.

Death Rate.

The death rate from collar pruning, when correctly performed, depends of course largely on the condition of the bushes, but on the average does not exceed 2 per cent. The bushes that die were so unhealthy that the plantation is better without them. In the course of time, therefore, in the great majority of cases, a few shoots burst forth from the margin of the section and are trimmed and brought into bearing in, say, eighteen months. But the dead central wood of the old stem in high collar pruning is very often decomposed, or eaten away by white-ants, and the new shoots are then seen to be living on a shell (perhaps only half an inch in thickness) at the top of what represents in consequence but a small portion of the circumference of the original stem. The stem has been gradually eaten away until the bush, supposed to have been completely renovated by collar pruning, is now found to be subsisting on the apex of a great open decomposing scar that may extend from the level of the collar-pruning section right to the ground.

Decomposition of Stem.

Bushes Growing on Rotten Stumps. *Conf. with paras. 225, 674-5.*

White-ant-eaten Stems.

In walking through a garden of this nature there would be no great risk in undertaking to kick down a large percentage of such bushes. Where open scars do not exist, the stems may be found to be completely excavated by white-ants and the place of the wood taken by the mud deposits carried up as a support to the bush while the ants complete their destruction.

221. Collar pruning that results in the destruction of the stem, is worse than useless, for it causes an injury to the plant far greater than the evils it was intended to cure. It is needless to attempt to portray the irreparable injury done by this kind of pruning. I have before me now all that constituted a bush. The original stem (left after collar pruning) was 12 inches high. It is now represented by a shell on one side, nowhere more than an inch thick. On the apex are three sickly branches, 6 inches in height, that support eight wiry useless flush-bearing twigs. The garden from which that bush was cut has given an average of 17 per cent. profit to its share-

Stem Decomposed.

Living on a Shell of Bark.

holders for the past four years. In the part of the estate where it was found a considerable number of bushes were of the same nature and manifested, as the superintendent said, all the evil effects of high collar pruning. Four years ago the bushes had been collar pruned to 12 inches. It would be well within the mark to say that 20 per cent. of the bushes of that plot were found standing on rotten stumps, but I have seen many gardens where it would not be incorrect to affirm 50 per cent. of the bushes were in that condition.

IMPERFECT COLLAR PRUNING.

Prevalence of this Condition.

The shoots from the top of the stumps had been repeatedly pruned, the soil had been deep hoed and top dressed, but nothing could redeem the mischief, excepting to collar prune once more and to do so effectually.

I have chosen this illustration from one of the most prosperous of gardens in Assam, in order to show that it is the manner, not the principle, that is wrong. Indeed I regard this method of collar pruning as one of the most serious defects of the industry, and it is very widely practised. With perhaps half the bushes it may appear fairly successful for a time and even give a good return. But a few years plucking will invariably reveal the fact that it was a false economy to retain any portion of the stem. As exemplifying the generally accepted usage, I may give the following quotation from Mr. D. Crole's recent work :—" Experience shows that the bushes usually require cutting down to the ground once every half-dozen years or so. This is done by sawing across the stem, *about 6 inches from the ground*, in a distinctly slanting direction ; the surface is then smoothed off with a heavy pruning knife, and is finally coated with a warm mixture of tar and bees'-wax, to prevent the rain lodging in any cracks or crevices and so rotting the wood, and then manure is applied round the plant. Bushes thus treated will not yield any leaf till well on in the season, and not much even then ; and the next " cold weather " they are either left unpruned, or, at most, only slashed across the top ; but the second season they usually bear a splendid lot of leaf, adequately repaying the severe treatment they have undergone by subsequent vigorous flushes in quick succession." The italics above are mine and have been given in order to draw attention to the passage to which I take exception.

Serious Defect.

The Objectionable Form of Collar Pruning.

Tar.

Conf. with para. 225.

XXXVI.—Collar Pruning Satisfactorily Performed.

222. ***Low Collar Pruning.***—While one cannot condemn in too

Collar Pruning.

IMPERFECT COLLAR PRUNING.

strong terms collar pruning of the nature indicated in the foregoing paragraphs, collar pruning properly performed gives a complete renovation to exhausted bushes.

Low Collar Pruning Desirable.

During my visit to Meleng, on the 24th April 1895, I had some conversation with the superintendent of that garden on this subject. An abstract from my diary may with advantage be here given:— "Replied to Mr. Reid's enquiry that I most thoroughly approved of the principle of collar pruning, but totally disapproved of the manner in which it was practised. In my opinion the planters are far too timid in their treatment of the plant. The majority seem to be reluctant to part with the old wood, a surprising fact, since it is the chief cause of the depreciated yield. Mr. Reid then asked me how I would propose to collar prune. Replied that there seemed to me no doubt that the section should be made about a couple of inches below the surface of the ground, and that the wound should be immediately earthed over. Mr. Reid then remarked I am very glad to hear you say that for some years ago I came to the same conclusion· I cut down all the bushes of a large plot of land and my friends told me I had made a race course of it. I should like to take you to see the bushes as they are now."

Branched from Below Ground.

223. The plot of land to which the above conversation had reference was one of the finest I had seen in Assam. I examined a number of bushes, the earth having been cleared away from the stems, and in every case no indication of the saw having been used could be found. Three, four, or more stout branches were seen to rise from the apex, of what might be described as a short, thick, underground stem, but these had so united together that all trace of the collar pruning scar had been completely effaced. This is an example of how collar pruning can be done with great advantage. But with a certain number of bushes where the section across the stem had been made a few inches above ground, a very large percentage existed in the condition I have described as on stumps of old rotten wood.

There could not be found a better object lesson of the two systems than the plot of land to which I allude.

Collar Pruning Preferable to Repeated Heavy Pruning. *Conf. with para. 211.*

The description of defective collar pruning, given in the foregoing paragraphs shows, moreover, how very accurate Mr. Lindsay Alexander's observation is that collar pruning is preferable to heavy pruning on the common stem. But I desire still further to add

another instance in support of my recommendation. While visiting the Brahmaputra Company's Gardens in 1895 I discussed with Mr. A. B. Holmes (the Superintendent) the advantages of collar pruning below ground. In consequence he decided that during the coming cold season he would act on my suggestion. In 1897 I paid a flying visit to the same garden and was taken to see the result. Less than one per cent. had died or had only begun, after fully 18 months, to show signs of sprouting. The rest of the plot consisted of magnificent bushes that were already fully 4 feet in height. Mr. Holmes expressed himself as fully satisfied that the experiment had been a splendid success. PERFECT COLLAR PRUNING.

224. ***Conditions of Collar Pruning.***—These remarks on collar and heavy prunings may, therefore, be summarised :—

(1) Collar pruning should be made in January or even in February, only occasionally or when unavoidable at an earlier date. *Conf. with para. 220.*

(2) The position of the section should be as low down as possible, preferably below, rather than above, the level of ground. *Conf. with paras. 183, 186, 193.*

(3) The wound made should be immediately covered over with a sprinkling of light pulverised soil sufficient to protect the exposed wood from the action of the atmosphere (see No. 5 below). *Conf. with para. 222.*

(4) Heavy pruning should never be made through the stem nor low down on the main branches; when either is indicated collar pruning is preferable. *Conf. with paras. 211, 217.*

(5) The exposed sections of the branches produced by heavy pruning should be at once painted with the Gondal fluid. This will be found more fully discussed under the Chapter on White-ants. The object of the coating is to protect the wood both from the atmosphere and white-ants. In several instances where tar had been used for this purpose, the bark had been killed. The Gondal fluid I regard as superior to any other substance as yet discovered and it might with great advantage be used in collar pruning before being earthed over. Gondal Paint. *Conf. with para. 708.* Tar. *Conf. with para. 221.*

(6) Before collar or heavy pruning, the bushes should be allowed a short rest, the soil should be deep hoed and, if possible, manured to encourage vigorous growth and thus check the severity of the shock.

Pruning.

DIARY NOTES.

Diary Notes on Pruning.

225. It may serve a useful purpose to give here a selection from the passages recorded in my diary on the subject of Pruning. To some extent these no doubt repeat the opinions I have already offered, but they indicate the extent to which they are held (or it may be opposed) by some of the practical men, whom I had the pleasure of meeting, during my tour through the Assam tea districts. It will be seen that I have purposely suppressed the names of my informants or the gardens they are in charge of, the exception being in a case where I have reason to think the liberty I have taken may not be viewed as objectionable.

Large *versus* Small Plants. *Conf. with paras. 176, 195, 200.*

Notes on The General System of Tea Pruning in Assam.—At a meeting of planters (April 10th) I encouraged a discussion on the advantages of heavy pruning *versus* collar pruning. It was held that plants more than 4 feet in diameter did not yield so much as smaller bushes. In other words, if the spacing could support two plants 2½ feet diameter the return would be far more than from one of 5 feet.

Bearing Age. *Conf. with paras. 214, 274.*

Uprooting. *Conf. with paras. 211, 280-81.*

It was upheld, however, that there was practically no limit to the age and bearing capacity of tea and that ordinarily it could not be said that uprooting and replanting would ever be indicated. But it was freely admitted that old plants that had been repeatedly pruned, acquired a large amount of useless wood so that collar pruning became necessary if this resulted in time to the breaking up of the plant into many stems which after years had each a superabundance of wood, uprooting in such cases might then become necessary. It was also held that the practice of repeated pruning must necessarily result in the production of much useless root corresponding to the useless stem, so that badly formed old bushes with much injured stems and useless wood, might be assumed to be the same below ground. Hence uprooting no doubt would have to be followed systematically all over estates that were 30 to 50 years old.

Bush on Stumps. *Conf. with paras. 217-21, 674-75.*

White-ant.

Bushes on Rotten Stems.

Defective Collar Pruning.—On the 11th April I visited a garden and examined the effect of what was called collar pruning. In the old part of the garden where this practice prevailed (some years ago), the old stems were in nearly every case rotten and consisted of a shell of living bark, bearing the main branches not more than three-quarters of an inch thick. In very many instances also the shell that spilt into separate rotten stumps, each bearing one or two unhealthy branches. The decaying central wood was, moreover, seen to have become a *nidus* for pests of all kinds. White-ants had in every case filled the interior with earth until a more or less compact-looking stem of an utterly useless nature had been formed. The bark on being broken revealed the earth stem and this in many examples was found to extend right up the branches until it might fairly well be said that the leaf-bearing portions of the plant were dependent on less than half an inch of wood In other instances plants were found where all the tissue had been decomposed and fallen away, so that the plants stood on stumps with a bark on one side and a large open scar of wood on the other, a foot or more in length, which corresponded to the old stump of the so-called collar pruning. It was thus quite evident that the collar pruning of the old garden had been made 6 or 8 inches above ground. Collar pruning was thus, as I had learned in several other gardens, a loose term that denoted cutting through the main stem below the lowest branch. A stump is thus left above ground and exposed to the action of the weather and to white-ants, with the not unnatural consequence of the destruction of the wood throughout the length of the stump and the production of what I have designated bushes standing on rotten stems.

Pruning.

DIARY NOTES.

Direction of Section. *Conf. with para. 218.*

It was thus clear to my mind that if the so-called collar pruning is to be followed above ground, the stump must be cut on a slant so as to allow water to flow off it naturally. It should in addition be painted with tar or better still with my Gondal fluid to prevent it from being killed, through the exposure of a large surface of wood to the weather and the ravages of white-ants. The rim of bark as it rises up to cover the cut surface would not in that case form a cup for water to lodge within, a condition of affairs which, if permitted, sets up decomposition of the wood. But the cut surface should be perfectly clean, and if sawn it might with advantage get a subsequent dressing with the knife. Every little irregularity will favour the evil of collar-pruned surfaces exposed to the dangers I have mentioned.

Snags. *Conf. with para. 183, also Fig. 3, X.*

Wood-borer. *Conf. with para. 393.*

There appears, however, no doubt as to the immediate value of collar pruning. A plant with an erect stem 12 inches or more in height comes to form a broom of short distorted branches through the action of each succeeding pruning. The bush, in other words, gets gnarled and has sooner or later a crown of short unnatural branches and twigs. This is accounted for largely by the fact that the fresh shoots do not necessarily occur at the point of severance effected by the knife. The sap forced to the actual points where the new shoots are being formed, causes a swelling to take place and deprives the portion above that of its nourishment. The subsequent action may be said to be that on this terminal portion the bark first dies, the old pruned stumps then decompose down to the swelling and into it until such swellings become secondary breeding places for pests, more especially white-ants. These cut ends also give openings to a wood-borer that works down the stem, tunnelling a way for further destruction and completing the gnarled condition so characteristic of all old gardens where the one stem system has been nursed as an essential condition of successful planting.

Second Collar Pruning. *Conf. with para. 211.*

With a hoary stem of half a century's growth of useless wood and a dome of poor flushing stuff, collar pruning is undoubtedly an immediate cure. Good results follow as may be seen in many gardens where collar pruning has become an established principle. But what I anticipate is that timid operators will some ten years hence not be so enthusiastic about their pet theory of leaving 6 to 9 inches of the good old stem as the foundation for the crop of new shoots. Unless they take the greatest care they will find a high percentage with a rotten stem not only down to the ground but along the central roots. Second collar pruning will, in the majority of such cases, be impossible, and uprooting and replanting the only cure.

Early Pruning of Seedlings. *Conf. with paras. 186, 189, 199, 205, 210-11, 244.*

Early Pruning.—On the 24th April, I inspected a garden that had two portions of widely different nature. The old garden, inferior light soil yielding poor tea of mixed *jat*. New plantation 2½ years old had been cut at one year eleven months, the plants had branched freely but were subsequently cut down to 9 inches. Certain plants here and there over the plot that looked seedy at the time of pruning were not cut and are now standing with stems 5 feet high and branched all the way up instead of as in the others branched nearly from the ground. The comparison was distinctly in favour of the early pruning.

Collar Pruning Doubted. *Conf. with para. 207.*

Collar Pruning not approved.—At a garden in Jorhat, I saw much tea that had been collar pruned, as I was told, in 1861-62. It was added that 20 per cent. had never recovered. The superintendent accordingly believes that a large percentage always suffers and he is, therefore, doubtful of the wisdom of too freely adopting the system of renovation by collar pruning. He further told me that he does not think collar pruning at all necessary, its place being easily taken by systematic heavy pruning.

Pruning.

DIARY NOTES.

The bushes in the year following heavy pruning, he said, should be plucked, but not at all pruned. I need hardly add that the collar pruning in question had been done some inches above ground, so that I was personally not surprised at the result that had been obtained. But I should not be at all astonished if 50 per cent. of the garden, as seen at the present day, had been entirely renewed by the system of filling up vacancies.

Bad Collar Pruning.

Bad Collar Pruning.—In a garden visited on the 2nd May in the Golaghat Sub-Division I found that collar pruning had been done some six years ago but with stumps 6 inches high. This now showed at least 30 per cent. of plants standing on stumps. The superintendent admitted that collar pruning below ground would doubtless give better results, and added that he was to do so in future.

Comparative Trial.

Comparative Trial of Heavy versus *Collar Pruning.*—While at Panitola I encouraged a discussion among several planters (June 19th) on the subject of Collar Pruning. They agreed with me that much damage was done through decay of the wood of exposed stumps. The late Mr. Madden took me to see a garden where a comparative trial had been made; the collar-pruned bushes stood on one side of a road that ran through the plot, and those severely pruned, but not collar pruned, stood on the other. The stumps of collar pruning had been tarred. The process of tarring the stumps had employed 20 boys to the acre, so that it was not expensive and the result was very striking. No decomposition of the wood had taken place on the tarred portion, whereas on the opposite side of the road, where tarring had not been resorted to, 30-40 per cent. of the plants were seen to be now standing on stumps, 9 inches high. The only cure for the portion that had not been collar pruned and tarred was to pruning a second time. But Mr. Madden admitted freely that many of the bushes had been so badly injured that they had better be entirely exterminated and replaced.

Uprooting. *Conf. with paras. 280-1.*

Pyramidal Bush. *Conf. with paras. 186, 199.*

Pyramidal Pruning.—In a garden visited on the 26th June (in the Dibrugarh District) I found the plants large, well-formed, many of pale-yellow colour. The most striking peculiarity, however, was that they had been pruned into a conical shape by the encouragement of the growth of the central bud. This result had been obtained by delaying the heavy pruning of the main axis of seedlings, while encouraging at the same time the production of lateral branches. It looks fairly well in mid-season, when the bushes are covered with leaf, but in the early months, the superabundance of wood results in the garden appearing like a large harbour, the central useless wood then appearing like masts. This state of affairs I had previously seen in Golaghat and elsewhere, but cannot say I am prepossessed in its favour.

Early Pruning of Seedlings. *Conf. with paras. 186, 189, 205, 210-211.*

Pruning of Seedlings.—In a garden of the Dibrugarh District (visited on the 27th June) the superintendent told me he believes in cutting down one year old seedlings to about 8 inches and even later on, should a central stem show prominence, it is again heavily cut back. He did not at all approve of a conical system of pruning which he said (and I thought justly so) resulted in the formation of much useless wood that would give great trouble in future and had no compensating advantages.

In another garden I examined some admirable examples. The bushes had been pruned when under one year old. They are now completely branched and right from the ground and are in a very natural and healthy condition.

CHAPTER VIII.

PLUCKING.

XXXVII.—Continuous Production of New Shoots.

Plucking, a Method of Pruning. *Conf. with paras. 54, 60, 166, 178.*

226. It has already been remarked that plucking should be looked upon as a method of pruning; further that the planter prunes in order that he may subsequently pluck.

Production of Seed.

By pruning and plucking the tea plant is forced into the artificial condition of continually producing young shoots and is debarred from ripening wood, with the view to the ultimate realization of the perpetuation of its species in the production of seed. It has been contended, in the foregoing chapters, that this is, of necessity, an exhausting and weakening state that predisposes the individual to disease. Consequently it has been upheld that the most hopeful and rational method of attempting the mitigation of the danger that is year by year assuming greater and more alarming proportions, would be to effect such improvements in the systems of cultivation that may be calculated to increase the health and vigour of the plant.

Predisposition to Disease. *Conf. with paras. 30, 47, 99.*

Improvement in Cultivation.

Injurious Influences.

227. Plucking being the ultimate aim of the planter it will be readily understood that around this simple act gravitates all the other injurious influences that are brought to bear on the plant. Under paragraph 206 I have endeavoured figuratively to express what might be called the Flushing Power of the plant. During its first three years it has to be assumed there have been produced a system of roots for the collection of food and also a frame-work of branches sufficient to nourish and support the flushing shoots. Future success, it has been urged, depends almost exclusively on the character of the young plant. It must possess by the end of the third year, both the strength to endure and the material to allow of a systematic annual pruning for the flushings demanded, during a term of not less than nine to ten years. I need not recapitulate my views as to the shape of bush it is desirable to obtain, but there is one point that has a distinct bearing on the question of flushing and which may, therefore, be here alluded to. By the system of allowing the seedling to grow undisturbed for three years and then cutting it down to 9, 12 or 24 inches, the shoots that originate from the stump are considerably less than one year old when

Flushing Depends on Character of Bush. *Conf. with paras. 43, 186.*

Age of Primary Branches. *Conf. with paras. 211, 221.*

Plucking.

CONTINUOUS PRODUCTION of SHOOTS.

they are plucked. This, I am convinced, is a serious mistake. These twigs have subsequently to become the main branches to carry the flushing shoots, and they should most certainly be allowed more than one year to mature wood before being in any way interfered with.

Check to Growth.

228. It is the sudden check given by plucking, to the development of healthy wood, that is, the chief injury the plant has to battle against. When the extremity of a shoot is nipped off, the effort to mature wood that had perhaps just then commenced, is suddenly arrested, for the young leaves are the lungs and, to some extent, the mouths also of the plant. It has thus become a more imperative obligation on the plant to replace the parts removed, and in consequence return to the duty of development of wood is tardily performed. The lateral buds that may be seen nestling within the little recesses formed by the leaves at the points of their union to the twig, accordingly burst forth and elongate into saplings to take the place of those removed. No sooner, however, have these grown to a certain extent than they are plucked, and the process of wood forming once more deferred. But the third set of flushings that must now come are, of necessity, borne upon less mature wood than the first. Time after time this is repeated, for perhaps 20 to 30 times a year, and each succeeding flush is, therefore, borne on less mature and still less mature wood than its predecessor.

Less and Still Less Mature Wood. *Conf. with para. 178.*

Flushing Power. *Conf. with paras. 178, 206, 225.*

229. This then is the state of affairs that prevails during the flushing season. For eight to nine months a year there may be said to exist a struggle on the part of the roots to cause the production of young shoots, in order to assimilate the continuous supply of nourishment which they are draining from the soil. By pruning the balance between the condition of root and stem has been disturbed. The roots are now rendered capable of nourishing a larger number of shoots than exist. The production of shoots is, therefore, the Flushing Power of the plant determined by the pruner's knife. But it is needless to say, this again is but the expression above ground of the state of affairs that prevails below. A sufficiency of young and vigorous roots and a liberal supply of food materials are indispensable to the response being given by the plant to the degree of pruning to which it has been subjected.

Balance between Root and Stem Disturbed.

Banjhi Buds. *Conf. with paras. 50, 79, 206.*

230. ***Banjhi Buds.***—It will now be seen that it would be irrational to prune beyond the ascertained flushing capabilities of the plant.

Plucking.

Planters in Assam are familiar with the condition known as *banjhi* (barren) buds. Instead of elongating to the extent necessary to allow of plucking, the terminal bud of each little shoot seems to sulk and the leaves that have already unfolded from it have become dark-coloured and matured before they are half their natural size. The bush is then spoken of as "*banjhied.*" Perhaps regarding few other aspects of tea plucking could a more animated controversy be aroused than as to the proper method to treat bushes in this state. Should the buds be left on the bush or plucked off? That is the question asked on every hand. Now were the buds injured in any way and *banjhi* in consequence, the lateral buds on the shoot would sprout forth with as much vigour as if the terminal bud had been plucked. It accordingly follows that we must assume the inactivity of the buds is but the expression of a want of energy in the entire plant. To force it, therefore, into activity by plucking the terminal buds may injure it materially. It has possibly been already overworked, the food supply may be insufficient or the climatic conditions unfavourable; it may be suffering from some specific disease, or its stem may be so gnarled and rotten as to be unable to support the excessive growth demanded. The cause must be sought and cured. In the majority of cases manuring and a good hoeing will suffice to cause the *banjhi* buds to once more resume activity. Mr. David Crole is of "opinion that early in the plucking season all '*banjhi*' leaf, whether single or double, should be severely eliminated from the bushes." "I have myself tried experiments in this matter, and, to the best of my judgment, they answered my expectations." After alluding to the uncertainty of experiments not "conducted under circumstances which render a careful comparison of the results over a long period (say several seasons) at the same time easy and certain, so that a reliable average may be arrived at whereupon a fair judgment of success or failure may be based," he adds, "Anyhow, I suggest the experiment as one well worthy of trial, and I am confident that it may be carried out without any risk of its affecting the flushing of the bush adversely." I need hardly add to the above that I regard Mr. Crole's recommendation as opposed to the planter's best interests.

CONTINUOUS PRODUCTION of SHOOTS.

Treatment of Banjhied Bushes.

Should not be Plucked.

Conf. with Peal's Account, Tea Planter's Vade Mecum, p. 99.

Plucking Recommended.

231. ***Abandoned Tea.***—It is a well-known fact that tea that has been abandoned for a few years, because of its having become so persistently *banjhi* (barren) that it was unprofitable, is found when again

Abandoned Tea.

QUANTITY PLUCKING.

Rest to Soil and Plant.

Conf. with paras. 68, 224.

brought under cultivation to have vastly improved. This may be explained as due to two causes:—

(*a*) The rest given to the soil through the sort of rotation afforded to it by the unrestricted growth of weeds (fallow).

(*b*) The reparation of the defects in the bush through the rest. Being not called upon to flush it has time to mature wood to the extent necessary to sustain flushing. Moreover, the circulation of the sap becomes established by its having time to work off the obstructions caused through pruning.

Reasons for Improvement.

Both plant and soil have been brought into a healthier state. This supports in the strongest manner the argument that heavy and constant plucking weakens the bush. It causes the flushing to be made on imperfectly matured, gnarled and snagged twigs. Pruning becomes, therefore, an imperative necessity, the knife being made to go as far back as possible, in other words, on to the well formed red shoots of last year.

XXXVIII.—Plucking for Quantity or for Quality.

232. Two systems of plucking may be said to be met with in Assam. The one might be designated plucking for quantity, and the other for quality. These systems differ mainly in the age of the shoots, and, consequently, in the number of buds they bear at the time of plucking. The engraving below (Fig. 2) will be found to indicate these two conditions.

Three Leaves and the Terminal Bud.

233. ***Quantity.***—The normal Spring shoot (A) has been allowed to elongate from the apex of last year's twig, [(*h*) being the section of light pruning made last Autumn], until it has produced eight lateral and one terminal, or, in all, nine buds. It is then plucked between (*b*) and (*c*), the portion removed containing three leaves, and the terminal bud. As a result the bud (*c*) or the buds (*c*) and (*d*) or sometimes also even (*e*) are forced to develop. It is not desirable, however, that the bud (*e*) should elongate at present, and this only exceptionally happens, the usual thing being that the buds (*c*) and (*d*) are developed. At the end of the season's plucking the next light pruning would have to be made at the point indicated by (*i*), so that one, two or three shoots might next Spring be expected, namely, from the buds (*e*), (*f*) and (*g*). It will thus be seen that the flushing shoots (*c*) and (*d*) with all their subsequent ramifications are pruned off, by the section being made into the original Spring

QUANTITY PLUCKING.

shoot at (*i*.) Much, therefore, of this season's flushing and of next year's Spring shoots depends on the method of treatment bestowed on the Spring shoot (A) or (B) in Fig. 2, presently under consideration.

Imperfect or Phaki Leaf.

234. ***Phaki Leaf and Bud.***—It may be here explained that the first leaf, unfolded from a lateral bud, is imperfectly formed. Botanically this no doubt would be designated a bud-scale; by the Assam planter and his garden operatives, it is generally spoken of as the *phaki* (useless leaf). In the engravings (Figs. 2 and 3) this appears at (*g*), (*j*), and (*l*). It is desirable that this scale should be clearly observed, for although useless as a leaf, it still carries in its axil a bud, quite as capable of future elongation as any of the buds subtended by fully formed leaves. It may also be added that the *phaki* leaf is very caducous, that is to say, it falls off the twig at an early date, so that though shown on the fairly old shoots, represented by (C) and (D), it would not usually be seen in such cases. Occasionally several *phaki* scales may be found crowded together at the very base of shoots, and it is these obscure buds that in after years mainly furnish the shoots that sprout from old branches after heavy pruning.

Many Phaki Buds.

Accessory Buds.

Conf. with paras. 193, 225, 273.

First Plucking.

235. ***First Plucking Causes First Flush.***—But to return to the subject of plucking the shoot (A), the portion indicated to be removed is the first plucking and is made in order to cause the first flushing, so that the second plucking is designated the first flush. I understand that in China and Japan, the first plucking is reported to yield the finest tea of the season; that is certainly not the Assam experience, and most planters say the shoots are nipped purely and simply to start the flushings since the tea made from tipping the normal Spring shoots is very inferior. It is probable the majority of planters would agree in regarding the second flush as affording the finest tea, but the Autumn flushings have a peculiar flavour much admired by many persons.

Second Plucking or First Flush.

Seush ds the Affon Teas. Finest

In plucking for quantity, or rather for weight, it is usual to allow all subsequent flushing shoots to elongate till they have produced six lateral and the terminal bud, so that on plucking these (by removing three leaves and the terminal bud) only three instead of five buds remain, as was the case with the first plucking. There are many variations, however, in plucking for quantity, but these details had best, perhaps, be discussed after plucking for quality has been briefly indicated.

Shoots with Six Lateral Buds.

Plucking.

QUANTITY PLUCKING.

Conf. with para. 269.

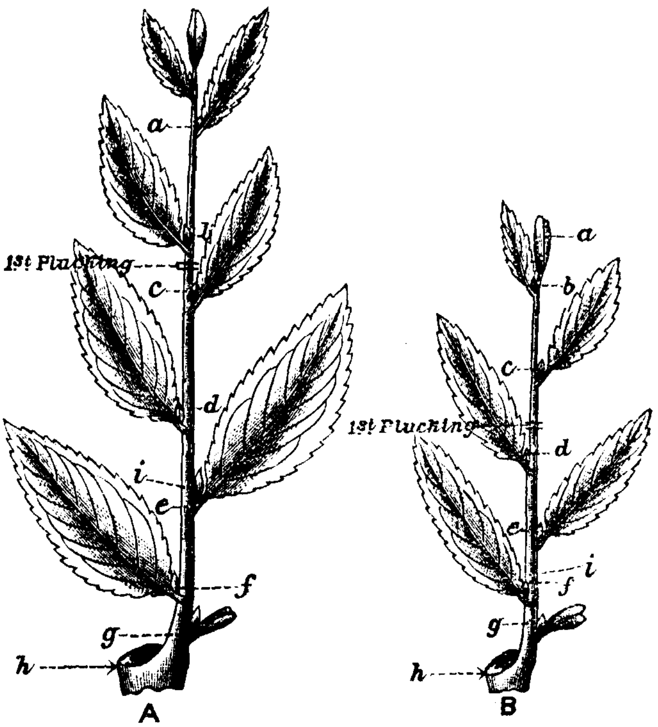

FIG. 2.—FIRST PLUCKING ON SPRING SHOOTS.

In this illustration (A) shows the condition of the plant when about to be plucked for *Quantity*, each shoot having nine buds (including the terminal one) before it is plucked. (B) shows the condition when about to be plucked for *Quality* (seven buds). The double lines denote the points at which to be plucked. In the former five buds (*c*, *d*, *e*, *f*, and *g*) will remain, in the latter only four buds (*viz.*, *d*, *e*, *f*, *and g*).

Quality. *Conf. with Mr. Bamber's Explanation page 151.*

236. ***Quality.***—In this case the Spring shoot (B) obtained from the topmost bud, at the pruning (*h*), is plucked at an earlier stage than in (A), namely, when it has at most elongated until it possesses six lateral and a terminal, or in all seven buds instead of nine. It is plucked between (*c*) and (*d*) thus leaving four buds below and removing two leaves and the terminal bud. Subsequent flushing consists, for the most part, in the production of the buds (*d*) and (*e*), and the succeeding pruning would be made at (*i*), so that next year's

Next Year's Shoots.

Plucking.

QUALITY PLUCKING.

FIG. 3.—FIRST AND SECOND FLUSHES.

In this illustration (C) shows the effect of (B) plucked at (x), the buds (*d*) and (*e*) having developed into the first flushing shoots. (D) denotes the further result when these shoots have been plucked and the second flush developed. The letter (*h*) in (A), (B), (C) and (D) denotes the position of last Autumn's pruning; (*i*) points to the position of the next pruning; (*g*), (*j*) and (*l*) indicate the *phaki* leaves or bud-scales with their contained buds; and the projection at (*x*), beyond the bud and shoot (*d*) is a snag formed by imperfect plucking or pruning.

Conf. with para. 276.

Spring shoots might be expected from the buds (*f*) and (*g*), though mostly (*f*) only.

So far then it will be observed the differences between the (A) and the (B) systems may be briefly stated :—

Difference between A. and B.

1st.—The greater age of (A) as compared with (B) before plucking takes place.

2nd.—The removal of three leaves and the terminal bud in (A) instead of two leaves and the terminal bud in (B).

Plucking.

QUALITY PLUCKING.

3rd.—The portion of the original (what I have called the normal) Spring shoot retained as the wood to prune on during the ensuing Autumn, containing three buds in (A) and only two buds in (B).

Difference of Age of Shoots.

The consideration exhibited under the third point of difference is, therefore, the direct expression of the first, namely, the difference of age between (A) and (B) to allow of the formation of one extra bud. This usually takes from eight to ten days, so that plucking for quantity (weight) may be said to commence about a fortnight later than for quality.

The further pluckings differ, to some extent, according to the view held by the practical planter. In some gardens where quality is aimed at, the Spring shoots are at first permitted to grow as in (A) and are plucked between (*b*) and (*c*), though the subsequent pluckings follow the system that I shall now detail.

Shoots with Five Lateral Buds.

237. ***Treatment of First Flush.***—The first flushing shoots are accordingly allowed to grow until they have produced five laterals and the terminal bud. Two leaves and the terminal bud are then removed. This is designated plucking "two and a bud." Three buds * are accordingly left on the lower half of the first flushing shoots as may be seen in (C). One, two or all three, lateral buds may now elongate to form the second flush, and these are plucked when they have four lateral buds and the terminal, that is to say, three leaf-subtended buds and the *phaki* bud (*l*) in (D).

Two and a Bud.

Shoots with Four Lateral Buds.

238. ***Condition of Ultimate Flushing Shoots.***—Two and a bud are again plucked leaving one leaf-subtended bud and the *phaki* bud (*l*), to form the third flush. This system is then continued to the end of the season.

Usually the *phaki* bud does not develop unless forced to do so by the destruction of all the other buds above, so that the third and all subsequent flushings may be said to be from *one bud on each shoot.*

One Flushing Bud to each Shoot.

This then is the system of plucking for quality. The flushings take on an average seven days so that in good seasons the garden may be plucked once a week all over, or from 25 to 30 times during the flushing season. It is the aim of the planter to increase the rapidity of flushings and to multiply to the utmost the flush-bearing shoots, but from what has already been said, it will be understood

Multiplication Depends on Age of Spring Shoot.

* Two and the *phaki* bud (*j*).

multiplication of the flushing shoots depends very large on the age of the Spring shoot when first plucked.

QUALITY PLUCKING.

Two and a Bud with Portion of Third Leaf.

239. ***Two Leaf and Bud with Portion of Third Leaf.***—A sort of intermediate state between quantity and quality plucking may be said to be often practised. This may be illustrated by inspection of the engraving Fig. 2 B. The women on nipping off the shoot of two leaves and bud are directed to catch hold at the same time of the leaf (*d*), and carry away at least half of it along with the "two-and-a-bud." The superintendent of one of the largest gardens in the Tezpur District (where this system used to be followed, but since, I understand, abandoned,) informed me that the extra half or three-quarters leaf thereby obtained, represented about one-fifth of the total yield. They were thus practically plucking three and a bud (as in quantity plucking) from a shoot that contained only seven instead of nine buds. The yield obtained in that garden was on an average close on 15 maunds to the acre and some portions of the estate, I was told, gave as much as 20 maunds.

Yield of 15 and 20 Mds. an Acre.

Three and a Bud and Portion of Fourth Leaf.

240. I have not seen plucking, where, in addition to "three and a bud," a portion of the fourth leaf below was removed. From what Mr. Bamber says this would seem to exist, but he does not tell us where. I am fully aware that formerly not only a portion of the fourth, but portions of the fifth and even of the sixth leaves were removed. It seems probable that the rejection of the system of plucking portions of the lower and older leaves is a direct result of the introduction of machinery in the manufacture of tea. The preparation of Pekoe, Souchong and Congou teas separately, as formerly practised, necessitated the collection by itself of the Pekoe leaf, of the Souchong leaf, and of the Congou leaf, which by hand manufacture could be worked up separately. At the present day Assam teas may be said to be of two kinds, *viz.* (*a*) quality in which "two and a bud," the Pekoe portion alone is plucked, and (*b*) quantity in which the Pekoe-Souchong portions (three and a bud) are plucked at the same time and manufactured together. A tea that might be called Pekoe-Souchong-Congou (that is to say, "four and a bud") or three and a bud with part of the fourth (or even fifth and sixth), is not made in Assam at the present day, so far as I am aware.

Effect of Machinery.

Improvement in Quality of all Assam Teas.

Advisability of Tearing off Portions of Leaves.

Conf. with paras. 219, 255, 258, 260, 262 264, 267

241. ***Tearing off Portions of Leaves.***—But this leads me to the consideration of the question whether it is desirable to tear

Plucking.

QUALITY PLUCKING.

off portions of leaves (the system two and a bud with part of third). This has been advocated for, perhaps, 40 years, the argument being that the bud subtended by the mutilated leaf comes away more quickly than it would do were it left entire. I accept that statement as being possibly correct. No doubt so far as the necessities of sap assimilation are concerned, the mutilated leaf would be worse than useless. Before it could be employed, the injury done to its own structure would have to be repaired, and consequently the simpler course of producing a new shoot might be resorted to, but the half leaf left on the plant might just as well have been removed entirely. It has to be viewed as non-existent, so far as assimilation is concerned, and the increased yield through plucking the portion of the leaf, as also the advantage of breaking away earlier, might have been made up, far more rationally, by giving the time to form below three or very possibly four shoots instead of two, and then plucking three and a bud as in quantity plucking. By so doing the health of the plant would be secured conjointly with a high outturn.

Hastens Development of Buds. Conf. with paras. 262, 264.

Preferable to Pluck Three and a Bud.

242. From the point of view, therefore, of the health of the plant it is false economy to secure a higher yield by unnecessary mutilation, when by a more careful study of the buds, in the early plucking, the number of flushing shoots may be multiplied to any extent desired.

False Economy. Conf. with para. 238.

Severe Quality Plucking.

243. ***Severe Quality Plucking.***—So again in quality plucking many planters do not approve of the first flush being allowed to form five lateral buds and the terminal (Fig. 3, C.), but prefer to pluck it as in the second flush (Fig. 3, D.) when the shoots have only four laterals and the terminal bud. From the remarks that follow under the section on the number of leaves left on the plant, it will be seen that this system should be regarded as pernicious, judged of in the light of the health of the plant.

Two Flushing Shoots. Fig. 5H.

244. ***Two Systems of Quantity Plucking.***—In quantity plucking it is usual to continue throughout the entire season to pluck three and a bud from shoots in the condition shown by (C), that is to say, when they have five laterals and the terminal bud.

But it may even be occasionally found that the pluckings are still further deferred until the shoots have six laterals and the terminal, so that in every such case two leaf-subtended buds and the *phaki* bud are left below. In that case it may happen that two buds instead of one (as in quality plucking) may be said to be produced from

Bushes are More Open and Healthy.

each shoot, hence giving not only an increased return from greater size and weight of leaf plucked (owing to their being older), but in many cases through an actual increase of the number of possible flushing shoots. A bush under quantity plucking is of necessity more open (since each shoot has at least one extra leaf and corresponding internode) than in quality plucking. The leaves are more fully exposed thereby to light and air and become in consequence more fully developed and nourished. The plant is in fact very much healthier in the one system than in the other.

LEAVES on the PLANT.

I may here explain that I tested these statements regarding the different conditions in quality and quantity plucking, and feel confident they will be found correct. At Ligri Pukri, through the kind assistance of Mr. J. A. Thomson, I was enabled to test, by practical experiments, quality plucking, and at Nigiriting, through the facilities afforded me by Mr. A. B. Holmes, I similarly investigated quantity plucking. Of course I do not wish it to be supposed that every bud must, of necessity, be made to follow the rules indicated; the majority should. Improvement, as it seems to me, therefore, should follow the lines of a more careful study of the buds and their possibilities. It is a mistake to suppose that it is matter of little importance how many buds and leaves there may be on a shoot so long as the fixed rules of plucking are observed. The shape of the bush, the state of its health, and its flushing power, are all intimately connected with the number of buds it may possess. It is on the question of buds that I object to seedlings being allowed to grow for three years before they are pruned, since the shoots subsequently formed are too young and not sufficiently developed to be plucked the following season. No shoot that is destined to live on the bush for a number of years should be plucked sooner than two years from the date of its formation on the main stem.

Practical Lessons.

Influence of the Buds Present.

XXXIX.—*Number of Leaves Left on the Plant.*

245. ***Leaves Retained for Assimilation.***—I desire now to draw more direct attention to a point incidentally mentioned above, *viz.*, that on a Spring shoot, plucked for quantity, there must at least remain *four* leaves, and in quality plucking only *three* leaves. This is an important consideration, since the topmost leaves being removed the plant is dependent entirely on the leaves left to it, each succeeding year, to carry on the assimilation of its food. It may be taken as very

Assimilation.

Conf. with paras. 58-64.

Four Leaves on Quantity: Three Leaves on Quality Plucking.

Plucking.

LEAVES on the PLANT.

nearly correct that the previous year's leaves are practically useless for the purpose of assimilation.

Two Systems for Quantity, also Two for Quality Plucking.

But the foregoing remarks on flushing may be regarded as bringing out two main systems of plucking for quantity and a like number for quality. These result, when the first flush has been plucked, in very different numbers of leaves being left on the shoots. The following sketches of these conditions may be here given:—

Leaves after Plucking First Flush.

246. ***Leaves Retained in Quantity Plucking.***—There may be said to be two conditions. In (E) (Fig. 4) after plucking the *Spring Shoot*, the buds (*c*) and (*d*) produce flushes, or perhaps (*e*) also may do so. These flushings are not plucked till they have each formed four

In E. Six or Seven Leaves Remain.

In F. Eight or Ten Leaves Remain.

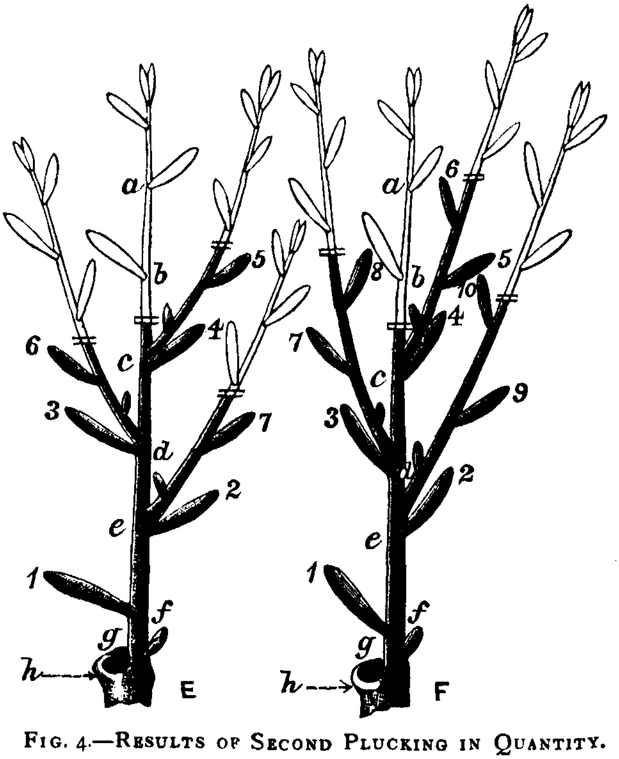

FIG. 4.—RESULTS OF SECOND PLUCKING IN QUANTITY.

The letters denote the leaves and buds of the Spring shoot as in Fig. 2 (A). The shoot (*a*)—(*b*) was removed at first plucking: the tips of shoots (*c*), (*d*) and (*e*) at second (=1st Flush). The dark portion with leaves numbered is what will then remain.

Plucking.

leaves, in addition to the *phaki*. In the two shoot condition (*c*) and (*d*) six leaves, therefore, remain, and in the three shoot form (*c*), (*d*) and (*e*), seven leaves. By another method (F), however, the two or, it may be, three flushing shoots produced, are each retained till they carry five leaves and the *phaki*, so that with two shoots, eight leaves remain, or with three shoots ten leaves, after plucking the first flush. **LEAVES on the PLANT.**

247. ***Leaves Retained in Quality Plucking.***—Similarly there are two parallel conditions in quality plucking :—(G) (Fig. 5) in which the flushing shoots are retained till they have each formed four leaves and the *phaki*, and the other (H) in which the plucking is made when the shoots have each only three leaves and the *phaki*. In (G), therefore, after the first flush has been plucked, seven leaves, and in (H) only five leaves remain.

In G. Seven Leaves Remain.

In H. only Five Leaves Remain.

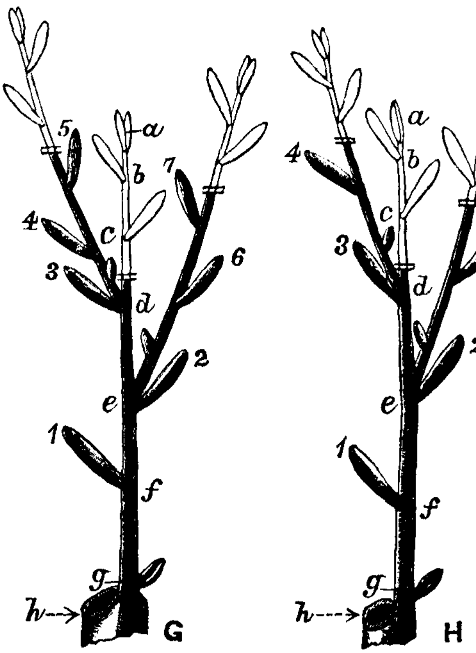

FIG. 5.—RESULT OF SECOND PLUCKING IN QUALITY.

The letters denote the leaves and buds of the Spring shoot as in Fig. 2 (B). Shoot (*a*)—(*c*) was removed at first plucking : the tips of shoots (*d*) and (*e*) at second. The dark portion with leaves numbered is what will then remain.

Plucking.

LEAVES on the PLANT.

248. ***Practical Conclusions that seem Justified.***—These diagrams thus figuratively express very important considerations in the systems of plucking. It is not desirable, and rarely occurs, that more than two shoots are formed on (G) or (H), *viz.*, the buds (*d*) and (*e*). The two lower buds (*f*) and (*g*) must be reserved as the stock on which the Autumn pruning has to be made.

Increased Outturn from Extra Shoots.

249. It will thus be observed that in quantity plucking, there is always the possibility of three shoots (thus giving an increased outturn) and further that a larger number of leaves remain on the shoot, with quantity plucking—(as in (F) its most complete form)—since the shoots in each case are allowed to produce five leaves and the *phaki*, before being plucked. But not only are there a larger number of leaves, but the additional interspaces between the leaves open the bush up and give greater facilities to obtain light and atmosphere.

Double the Assimilating Power.

250. Compare this with the state of affairs in the most refined system of plucking for quality that to some extent prevails, *viz.*, (H) where the shoots are plucked when they each contain three leaves and the *phaki*, and, consequently, at the end of the second plucking (*i.e.*, first flush) have only five leaves left on them instead of the ten leaves of (F).

251. The system of quality plucking represented by (G) may also be revealed as infinitely superior to (H), since after the second plucking, seven leaves remain instead of five, and the greater openness and additional few extra days' growth, must be viewed as giving a much-needed strength to the flush-bearing frame work. Indeed it would seem that were the system shown in (F) to be pursued up to the second pluckings, and thereafter changed into quality plucking, an even better result still might be confidently looked for. I commend this suggestion for careful consideration.

Practical Suggestion.

252. The system of quantity plucking exhibited by (E) is, I believe, the one most generally practised. After the second plucking the shoots will be found to have left on them six leaves, if only two shoots be produced; or seven leaves, when three shoots are formed. From the point of view that it is here desired to urge, the only improvement toward the health of the plant possessed by (E) over the quality plucking (G), is in the greater age of the normal Spring shoot and the greater age of the lateral flushes before either are plucked. In point of leaf remaining on the plant this is distinctly inferior to (G),

Additional Age of Shoots.

though the strength given to the shoots makes it superior in other respects.

OPINIONS of AUTHORS.

253. I have purposely tried to express the principles involved in the better systems of plucking, found by me to be practised in Assam, according to what might be called a botanical standard. I think the gradual development of the arts both of pruning and plucking, must follow some such lines and more closely than appears to have been the case in the past. I have read every book and report on tea cultivation that I have been able to discover, but in none of them will it be found that the positions of pruning and plucking have been defined according to the fixed positions of the buds. Indeed writers on these subjects have, as a rule, contented themselves by expressing their recommendations in general terms, so that it will be found none of them can be represented graphically with much hope of conveying the author's meaning. I trust I may be pardoned giving special prominence to these observations, as I cannot help feeling that something more definite must be evolved before our systems of pruning and plucking can be said to be directly adapted to the actual conditions of the plant and the requirements of tea planting.

General Terms.

Definite Action Necessary.

XL.—Opinions of Indian Authors on Plucking.

254. Following the system pursued in other chapters of this report, it may be useful if I exhibit a few passages selected from some of the better known authorities in order to exhibit the diversities of opinion and practice that prevail or have prevailed.

255. Mr. H. A. Shipp (a Cachar planter, 1865) says,—"The plucking season commences about the end of April and continues till the end of October, during which time a series of flushes occurs at intervals of twelve or fifteen days, according to the weather, and thus twelve crops of leaf may be gathered in one season." "The yield from an acre planted at 5 feet apart should be 280lb of green leaf, or 70lb of manufactured tea in the third year; double that in the fourth, and quadruple that in the fifth year, though care and high cultivation will give even a much larger return, as both in Assam and Cachar 7 maunds or 560lb of manufactured tea have been obtained from one acre."

Twelve Crops of Leaf in the Season.

It may be pointed out that in Assam the yield of 7 maunds an acre which Mr. Shipp thus, as it were, mentions with pride as

Seven Maunds an Acre Spoken of with Pride.

Plucking.

OPINIONS of AUTHORS.

having been obtained, is annually doubled by many concerns, and in some instances would seem to be trebled. Instead of 12 pluckings a year, one hears of 30 flushings with 10, 15 and even 20 maunds an acre as the annual output. It is somewhat curious that all this has been obtained without any compensating manure to the soil, and with teas of a higher instead of an inferior quality being produced. Is there no risk, therefore, that the plants are being overtaxed and are becoming diseased in consequence?

Plants Overtaxed.

Three Sets of Pluckers: 1st Took Two and a Bud.

But Mr. Shipp proceeds to describe the system of plucking pursued in his time. The coolies were divided into three sets. The first gang were designated the "Pekoe pluckers." These plucked off "the convoluted bud and its two expanded leaves." This then corresponded to the only plucking that is now-a-days made by gardens that go in for quality teas. Then followed the "Souchong pluckers." These plucked off the next two leaves and were followed by the third gang, or "Congou gatherers." Now, let us see what this meant. The "two and a bud" tips were nipped off and the two subsequent collections stripped the shoots of their leaves but left them their buds intact. The coolies were instructed "to pluck onwards and leave about a quarter of an inch from the eye or bud for the reproduction of fresh shoots." This system was therefore about as absurd as could well be conceived. The plants were alone saved from complete destruction through only half the number of pluckings being taken a year, as compared with the modern system. That circumstance no doubt allowed the shoots to grow to fully double the extent they are permitted to at the present day.

2nd Took Next Two Leaves.

3rd Took Fifth and Sixth Leaves.

Half Number of Pluckings a Year.

256. Mr. W. C. Muller (a Darjeeling planter who wrote in 1865) gives no particulars of the system then pursued except that "the young shoots alone are plucked." "By omitting to pluck the flush in time you not only lessen the number and rapidity of your flushes, but in order that the tree may flush again, you are compelled to pluck leaves which have grown so old and stiff that they are rolled with difficulty and break during this operation."

Young Shoots Plucked.

257. Colonel Money's chapter on Plucking is so involved and contradictory that nothing would be gained by discussing it in detail. Alluding apparently to the system of plucking separately the Pekoe "two leaf and a bud," mentioned by Shipp, he says, "It has been attempted again and again to do it, partly to the extent of taking the

Two and a Bud Will Never Pay.

Plucking.

Pekoe leaves *a*, *b* and *c** separate from the others (for the manufacture best suited to these upper leaves is not suited to the lower), but it has been as often abandoned, and I doubt if it is now practised anywhere. I am sure it will never pay." Fortunately for tea-planting Colonel Money's theories did not gain any very great hold on the minds of practical men and consequently the kind of plucking that, in the fourth edition of his work (published 1883), which he said would never pay, is that alone followed by perhaps more than three-fourths of the tea planters of India. To conclude this reference to Colonel Money and his system of plucking tea, it will suffice to give the following as fairly characteristic of the spirit of the chapter on this all-important subject, "Shortly, the principle I advocate is to prune severely, so that the plant in self-defence *must* throw out many new shoots; to be sparing and tender with these until the violence done to the tree is in a measure, but not quite repaired; then till September, to pick so much that the wants of the plant in foliage are never quite attained; and after September to take all you can get."

OPINIONS of AUTHORS.

Prevent Plant from Attaining Its Wants in Foliage.

Under such a treatment it was fortunate some consideration was given to the growth of shoots before the merciless plucking began.

258. Mr. J. F. W. Watson published in 1872 an account of tea-plucking. It is a very elaborate one and, to some extent, might be called a modification of that already given by Mr. Shipp. The tip, with its terminal bud and first leaf only, was to be taken off, and also the top two-thirds of the next leaf, but not its bud. This would be expressed by saying the first plucking was made between (*b*) and (*c*) Fig. 2 B, instead of between (*c*) and (*d*). Later on, when the wood of the shoots was supposed to have been formed, "two-and-a-bud" was taken and the two or three leaves below. This system had the advantage of giving an extra bud, thus allowing of one more flushing shoot, but the collection later on of the 3rd, 4th and 5th leaf, counting from the apex of the shoot downwards, must have weakened both the bush and the quality of tea. If quantity be desired, "three-and-a-bud" uniformly pursued would be both superior and simpler.

First Plucking One and Bud with Portion of Third Leaf.

Subsequently Two and a Bud.

Portions of 3rd, 4th and 5th Leaves Stripped.

Some of Mr. Watson's general observations on the importance of giving the bush some time to develop, in the early months of the

* This reference is to his plate on page 104—(*a*) the bud, (*b*) first leaf and (*c*) the second leaf of "two and a bud" modern pluckings. (as in Fig. 2 B. above).

Plucking.

OPINIONS of AUTHORS.

season, are valuable. On plucking he says depends "the yield of leaf (and therefore the outturn of tea), and the condition and health of the bush very greatly depend, to a greater degree than those not well acquainted with the cultivation of the tea would probably believe. Bad plucking will most undoubtedly tend to impair the vitality of the plant and will diminish its yield, while careful plucking conducted on sound principles will have the precisely opposite effects." "A good deal depends, in commencement, as to how the bushes have been pruned. If they have been cut down very low then the utmost care and circumspection will be needed in dealing with the new shoots, for these must be looked on as the *nuclei* of the future tree; for the bush as left by the pruner, it will be obvious, is hardly worthy of being called a *tree;* and was to *grow* to one, and if, therefore, care be not taken with the coming shoots, there will be no tree at all, and the pruned bush will just remain what it is. With bushes that have required little pruning, and are of good average size with no lack of young wood, the same degree of cautiousness is scarcely needed; or neglect, at least, will not produce disastrous effects, as in the other case." "Assuming that a bush has been from necessity pruned down to 18 inches in the close weather, leaf in the Spring month should be no consideration whatever, nor should ever be plucked till a good growth of young wood has been fully secured. No shoot should be touched if less than 8 inches long."

Bad Plucking Impairs Vitality.

Care Needed with Young Shoots.

Heavy Pruned Tea Should not be Plucked in Spring.

259. **Mr. T. G. Stoker** (a Cachar planter, 1874) has some useful and practical hints. His little work might almost be described as having been written in the transitionary period of old shoots subsequently deprived of their terminal bud and of the five or six leaves below and the modern school where "two and a bud" or "three and a bud" is uniformly taken. He says "I would suggest that the first flush should always be allowed to grow out, and that it should not be tipped until having again gone on and made three or four further leaves. I would never endeavour to increase the yield by plucking coarser leaf, but I would gradually do so by taking the flushes at a younger stage." "By letting the plants start unchecked, this great advantage is also gained, that the shoots not having been checked at first, they do not break from their lower axils, and fine clean wood is secured for next year's pruning."

First Flush Should be Allowed to Grow.

Plucking.

OPINIONS of AUTHORS.

260. Mr. S. Baildon (*Tea in Assam*) remarks that, "Plucking has to be watched most carefully, for if carelessly done, the garden will be thrown back to a very serious extent. Sometimes, instead of plucking in the way which they know to be correct, the women strip the leaves, by putting their hand below the lowest leaf to be plucked and then drawing it roughly upward. The risk is, that women will pluck a shoot too low down, and bring in coarse hard leaf which is not wanted, as it takes a long time to wither, and the good leaf becomes over-withered whilst waiting for the coarser, which acts as does China in breaking or bruising the fine leaf and spoiling the general appearance."

Difficulty in Withering.

Mr. Baildon then proceeds to describe the method of nipping off "two-and-a-bud" along with the upper half of the third leaf.

Two and a Bud with Upper Half of Third.

It may be said that the system of tearing off a portion of a third leaf was and indeed is (for, to some extent, it is still practised) a survival of the more barbarous system of stripping off two or three leaves below "the two and a bud" plucking. Fortunately the habit of tearing off even part of the third leaf is rapidly giving place to the more rational and definite methods of quantity plucking which I have already described.

261. ***Mixed Leaf.***—Mr. Baildon concludes his chapter on Plucking with a most instructive paragraph on the difficulty of both plucking and manufacturing leaf brought in from a mixed garden of Assam indigenous, hybrid and China bushes. "Assam and China bushes growing together," he says, "give more trouble to the planter than a novice would imagine. He must either take the China flush when that is ready, and sacrifice the superior hybrid and Assam leaf, or allow the China to grow until the other is ready, and then have uneven leaf brought in for manufacture, and this is a great nuisance. With leaf which would of itself make fine, good-looking tea, there is mixed up a lot of coarse, hard China leaf, and when rolled together the latter snaps, mixes with the good leaf, breaks or bruises it, and the manufactured tea, instead of presenting a good appearance for whole leaf, looks more like broken tea, with a lot of small, hard, flat pieces of China leaf standing out in bold relief, spoiling the appearance of the whole."

Difficulty in Working Gardens of Mixed Jats. *Conf. with paras. 72, 76, 79, 89.*

262. ***Notes on Tea in Darjeeling***—by a planter—commences the chapter on Plucking by the remark that, "Of course everything

OPINIONS of AUTHORS.

Special Treatment for Sides of Bushes.

depends on what sort of pruning has been done. And what sort of tea is wanted." It then continues, "In any case directly the bushes begin to shoot have a gang of coolies on taking out all the open leaf which shows. Put on a good many coolies, as if once the leaf is allowed to get ahead, it will be almost impossible to catch it up again." "Two leaves and a bud ought to be picked, but sides of bushes on no account touched until they get to level of rest of the bush. In the second flush again have the best people going round taking off longer shoots and leaving an extra two leaves." In the third flush leave one leaf again making five in all (if the growth is stunted), if it has run up well four leaves will be sufficient." "Thin out bushes as much as you can, and on no account leave too much growth from any particular flush, as the longer the growth you leave, so much longer will it take to harden up; and if the weather is cold, the next flush may be delayed for weeks." "Many planters advocate picking half the third or Pekoe-Souchong leaf, and say the flush comes on sharper if this is done. It may be so in the plains, but it is not the case up here."

Number of Buds Left Dependent on Vigour of Shoot.

Plucking Portion of 3rd Leaf Does not Hasten Flushing.

263. **Mr. M. Kelway Bamber**, (*Chemistry and Agriculture of Tea, 1893*), very truly remarks that, "The ideas on plucking are many and varied, and much has been written on the subject since the commencement of tea-planting in India. Some have advocated one method, and others an almost entirely opposite one, both giving valid reasons to justify their processes. The age at which plants are first regularly plucked also varies in different districts, but usually at three years; a light tipping being sometimes given at two years to assist in the formation of the bush. There are some who recommend hard plucking at the commencement of the season, and others who say pluck lightly at first, and gradually pluck harder as the season progresses. The number of flushes during the season averages 11 to 12,* and after a light pruning, the first is allowed to grow about six leaves before plucking commences, when the top two or three are taken, the second flush to grow about five leaves, and so on."

Hard *versus* Light Plucking at Beginning of Season.

Number of Flushes. *Conf. with paras. 238, 255.*

I refrain from detailed comment on the above passage which may

* In a further passage Mr. Bamber mentions that, according to Bruce, "the indigenous bushes of Assam only yield four flushes." Hence "It will be noticed that the rate of flushing has largely increased since tea-planting was first commenced." I have already stated that in Assam the flushings average from 20 to 30.—*G. W.*

Plucking.

possibly have been written as expressing an average of all conditions throughout the Indian tea districts. It could hardly be said to be applicable to Assam. But Mr. Bamber's remarks that follow are most instructive and deserve to be carefully perused (pp. 208-211 of his work) more especially the passages regarding the higher total extract and more tannin in young as compared to old leaves. "As tannin is the chief source of the strength of tea, the advisability of plucking young leaf is apparent, when thick liquoring teas are required."

OPINIONS of AUTHORS.

Explanation of Young Leaf Affording Best Tea.

264. Mr. David Crole (*A Text-Book of Tea Planting and Manufacture, 1897*), indulges in the usual indefinite mode of dealing with this subject, and accordingly lays down no rules. "About the middle of March, or at any rate during the third week of the month, the bushes produce their 'first flush' that is, they have sprouted sufficiently to pluck. The young succulent shoots are allowed to grow till four or five leaves are developed on each shoot. The bushes are very carefully plucked this first time of the season, in order to enable the bush to give a maximum yield during the rest of the year. It is most important, on the one hand, that the young shoots, to prevent them from growing too long and straggly, be nipped off in time and at the proper distance from the previous year's wood, and, on the other hand, that they should not be plucked too close to the old wood; for otherwise, in the first case, the sap will have too far to travel, and so the flushes will not follow in quick succession, while in the second the bearing surface of the plant will be seriously diminished."

Four or Five Leaves on Each Shoot.

Mr. Crole in a further passage says :—

"Theoretically, two (or three as the case may be) *whole* leaves and a bud, plucking is not so good as taking two and a *half* (or three and a half) leaves with the bud, which would leave the axils of the third and fourth leaves and the stalk between. The advantages are said to be :—

(1) the rapidity of flushing;

(2) the absence of unsightly stalks in the tea and the consequent greater facility in sorting the rolled leaf prior to fermentation."

Commends Taking Half Leaf.

Conf. with paras. 241-242, 255, 258, 260, 262, 267.

I have already expressed myself opposed to the system of carrying away portions of leaves, to increase the yield thereby, but I admit

OPINIONS of AUTHORS.

at once that there is force in the objection to an unnecessary amount of stalks in quality tea. I should sooner, however, prefer three shoots of the "two and a bud" type than two such shoots with the two halves of the third leaves. And that I think very nearly expresses the actual state of affairs that is likely to take place.

265. Let me repeat, therefore, by way of concluding this brief abstract of the opinions of authors, on the systems of plucking, that I am convinced much progress will be made by the careful study of the plant, until even more fixed and definite systems of plucking than we at present possess are evolved. This branch of tea-planting has, in my opinion, been greatly retarded through the indulgence, on the part of those who have come forward as authors, in such useless platitudes as "never pluck shoots less than 8 inches long;" "pluck the shoots when they have five or six leaves." It hardly needs explanation that a tea bush grown in the shade may run up a shoot close on a foot in length, but which may not contain more than three or four buds. Is there no difference between a shoot with five and one with six buds? There is, in my opinion, a very great difference; the difference perhaps in a yield of 8 and one of 10 maunds. But I fully admit that all the bushes of a garden cannot be made to produce shoots that contain a fixed number of buds at one and the same time. The whole art in tea planting centres nevertheless on the principle of plucking that may be inculcated.

Fixed Rules in Plucking Necessary.

Future of Tea Planting.

266. There no doubt may be many administrative difficulties in giving effect to hard-and-fast rules. What I am anxious to bring out is the fact that the different conditions I have tried to exemplify on a common standard of comparison, are not matters of botanical or theoretical interest. They are factors of vital importance to the tea industry, fully recognised in some gardens, and utterly ignored in others. The application of the reforms indicated I feel confident, however, may safely be left to the practical planter. Once satisfied that there may be something in a more careful study of the buds on a shoot, both in pruning and plucking, he will find the means to put into practice necessary reforms. I do not claim in this matter any discovery; my object has been and is to remove misapprehension as to the theory and object of the systems of plucking that may be said to be very generally followed. Progression can alone be expected when methods of procedure become something more than rules of thumb.

Factors of Vital Importance.

Misapprehension.

XLI.—Over-Plucking Injurious.

OVER-PLUCKING.

267. Mr. Christison, formerly a Darjeeling planter, appears to think this improbable. A paper in *The Home and Colonial Mail* (*January 1st, 1897*), which I am given to understand was written by that gentleman, contains the following :—"Under the methods in vogue for the last eighteen years or so, I cannot conceive any general danger to the tea plant from over-cropping. On the contrary, without resort to manuring as generally understood, I am confident that, given labour and ample judicious cultivation, the produce from the present bearing areas in India, as a rule, falls very far short of their safe cropping potentialities or what were in all cases originally the natural continuous productive capabilities of the soil. I do not venture to say over-cropping is impossible, but with careful, judicious pruning, under the present ideas of plucking for quality as I take them, it would not be easy, and must, I should say, be extremely rare. The tea crop is neither a heavy nor an exhaustive one ; and more nitrogen is undoubtedly restored to the soil in the shape of vegetation turned in (or that ought to be turned in) in cultivation also as derived from the atmosphere, and from the rainfall, than in more temperate climates. The average of green leaves taken annually is extremely light compared with the weight of agricultural crops (exclusive of the portion returned to the soil) in this country. Recent methods are supposed by some to be more of a strain upon the tea plant than the old. But I am of opinion that it is otherwise. In cropping for quality, the cutting in pruning is, perhaps, heavier over a majority of the years ; but, on the other hand, excessive cutting should be less frequent, and never to the same extent necessary. The pruning, therefore, should not be more exhausting. Plucking for quality necessitates going round the gardens very frequently, leaving the bushes with a constant layer of young shoots and leaves on (as well as the mature leaves) to perform all the functions of the foliage, and is not so trying as the old method of plucking at intervals twice or three times as great, commonly shaving off the flush to the very buds, so to speak. The shock to, and strain upon, the bushes was greater under the old method, and the temptation to overtax them more when, with an equal labour force, quantity could be more aimed at, the market not being so fastidious to anything but appearance."

No General Danger from Over-Plucking.

Weight of Green Leaf to Acre Light. *Conf. with para. 270.*

Quantity of Leaves. *Conf. with Figs. 4 and 5.*

Shaving off to the Buds. *Conf. with paras. 212, 241, 272.*

Plucking.

OVER-PLUCKING.

268. I confess that in several directions I am unable to follow Mr. Christison, in the above passage, and some of his deductions even seem to me to be scarcely justified by the premises put forward. On one point, however, I most distinctly hold the very opposite opinion, namely, as to plucking for quality being less hurtful to the plant than plucking for quantity. At first sight it no doubt seems as if Mr. Christison ought to be right, since quantity means a larger weight of leaf, etc., removed from the plant. But let it be recollected that to obtain quantity, as Mr. Christison very truly remarks, the intervals between the pluckings have to be by the old system, "twice or three times as great" as by the new. May it not, therefore, be inferred that the shoots in that case must be, to use Mr. Christison's own expression, twice or three times as old before being plucked; that their leaves have accomplished a far greater amount of assimilation and are themselves in consequence larger and heavier. May we not also be permitted to reason that the wood at the bottom of these shoots must also be twice or three times as well developed and its capability to bear still further flushings vastly improved; and, lastly, that the stem and its branches, as also the roots, must similarly have been immensely benefited.

Intervals between Pluckings Greater.

269. It is not the old mature leaves of a tree that are its active respiratory and digestive organs. It is the young soft green leaves that have to be depended on and those half an inch in length will practically do little more than half the amount performed by leaves double that size, so that the greater interval in plucking means, of necessity, greater strength to the plant in every direction. It will, I venture to think, be found that I am correct in the mode of reasoning by which I have demonstrated that there are more leaves left on a bush treated by quantity plucking than quality plucking. Under these circumstances I am unable to see in what way Mr. Christison justifies his statement that, after quality plucking "the bushes" are left "with a constant layer of young shoots and leaves." Moreover, as it seems to me, it very nearly follows that the opposite state of affairs, in the matter of pruning, must be involved by quality plucking, from what Mr. Christison would seem to believe was the case. If at the end of a season of thirty pluckings the bushes are found to be crowded with tufts of abortive and imperfectly formed shoots, the pruning back must be more severe in order to get to fairly well-formed wood with a sufficiency of

Greater Strength.

Conf. with para. 246.

Pruning Back More Severe.

buds for next season's operations. But I think that the manner I have already represented the different methods of plucking and the advantages of extra growth, are sufficiently clear, to render it unnecessary that I should dwell on these points any further. I might, however, figuratively express my meaning thus:—the Spring shoot of 1894 was in the Autumn pruned at (*i*) Fig. 2 (A), and only the shoot (*e*) developed in the Spring of 1895. There are thus two buds still available (*viz.*, *f* and *g*) before it need become necessary to prune below (*h*), the section made in the Autumn of 1893. Compare this with Fig. 2 (B) and Fig. 3 (C), and it will be seen at once that even one bud fewer in the one system, as compared with the other, must of necessity involve a corresponding degree of severity in pruning to obtain the flushings desired.

OVER-PLUCKING.

Result of Even One Extra Bud.

270. Before, however, passing away from the line of reasoning suggested by the passage quoted above, I should like to ask,—Is Mr. Christison correct, in the view he takes as to the weight of green leaf taken from the tea plant, being light as "compared with the weight of agricultural crops" generally? That may be so when judged arbitrarily as an annual return. But, as a practical agricultural problem, there can be no such comparison. It must not be forgotten that wheat and other field crops are sown afresh each year, and that in European agriculture the soil has the benefit of a rotation of crops. On the life of the plant, as on the preservation of the fertility of the soil, therefore, the results of the annual cropping of the tea plant are accumulative. After fifty years there can be no doubt that both the stock and the soil in tea cultivation will have suffered far more than would be the case with an annual crop. It is, consequently, of no advantage to the planter to know whether or not he is in any one year taking a greater or less weight of leaf from the soil than is the case with other crops. What he desires to know is, whether his plant and soil suffer more or less than is the case in other systems of agriculture.

Weight of Green Leaf.

Effect on Plant and Soil.

Conf. with para. 289.

XLII.—Deterioration in Yield and Value of Produce.

271. Mr. Christison, in the article already quoted, says, "There is no doubt that in too many instances the yield of old concerns, notwithstanding considerable extensions, has not increased proportionately, but in some cases may have even fallen off; but this, I believe, is due

Depreciation.

Conf. with paras. 198, 214.

Plucking.

DETERIORATION, Causes of.

(1), and I trust mainly, to the altered mode of plucking, which has been more for quality, (2) to blights, (3) on hill lands, to injudicious reckless cultivation and loss of soil from "wash"; (4) injudiciously heavy pruning, and, perhaps, (5) not infrequently to greater scarcity of labour than formerly; or to some or all of these causes combined." I agree most heartily in the combination of these causes, but not in the operation of any one by itself.

272. It is a little difficult to know what Mr. Christison means by "injudiciously heavy pruning." Does he include collar-pruning under that head? Without pruning, plucking would be impossible and the degree and nature of pruning pursued is largely, if not entirely, governed by the character of the plucking that is intended to follow.

Plucking for Cheap Teas.

Mr. Christison speaks of the old system having consisted in "shaving off the flush to the very bud." Certainly no such system exists in Assam at the present day, though plucking for "Whitechapel" teas is as well known as plucking for quality. In both cases the systems followed are those I have detailed, and if ever a lower shaving off of the flushings took place, than I have illustrated, there could have been remarkably few such flushes a year, for unless buds exist on

Adventitious Budding. *Conf. with paras. 193, 234.*

what remains of the shoot, flushings would very nearly be impossible, at least theoretically. I am fully aware the tea plant seems to possess the power of producing buds almost anywhere, even from its roots, as I have already remarked. But it would be a most unwise procedure to trust to adventitious budding and one calculated, moreover, to rapidly exhaust the plant. In other words, if plucking or pruning be carried below all visible buds, the production of new shoots becomes a remarkably slow process. What I presume, therefore, Mr. Christison's words may be taken to mean, comes to this, that instead of plucking when the Spring shoots had nine buds, they were left to grow for a week or two longer until they had perhaps a dozen buds. It might then have been a matter of indifference how far the

Advantage of Age of Shoots.

plucking was carried, and hence the expression of reckless action that would be implied by the words "shaving off almost to the bud." But if the interpretation of Mr. Christison's old system, which he thinks was worse than the modern plucking for quality, be correct, I am afraid I must beg to differ from him, since the greater strength given by the greater age of the shoots would have compensated for even inconsiderate plucking.

Plucking.

273. So far as I have been able to investigate the question there would seem no doubt that plucking for quality is distinctly more injurious to the plant than plucking for quantity. I believe also that I am near the mark when I say that the rapidity and extent of the distribution and multiplication of the number of pests and blights has kept pace with the extension of the practice of plucking for quality.

DETERIORATION.

Multiplication of Pests Accompanying Quality Plucking. *Conf. with paras. 33, 34, 166.*

274. There should, however, be no difficulty in putting my views to actual test. Let two plots of land, of as near as possible of equal merit of soil and within the same locality, be set apart for comparative examination. Let it be supposed that they are planted with identical forms of plant, the same distance apart, and pruned and plucked under precisely similar methods. In fact let the only difference be that the plants in the one plot are, say, 30 to 40 years old, and those in the other 8 to 10 years. Of course I am told the young plants will give a better return, but why? I shall answer that question, because they are younger and therefore more vigorous. And yet I have before me now several letters from planters of long experience who tell me there is virtually no limit to the yielding capacity of the tea plant. They assure me that a bush 40 or 50 years old, if properly cared for, will give quite as much as a bush 8 or 10 years old. I regret to say that I feel called on to protest, in the strongest possible terms, against that opinion being advanced, without its being supported by direct and careful returns of test plots, such as I have indicated. Personal opinions are very apt to be misleading in matters of this kind.

Experiment to Prove Deterioration.

Young Plants More Productive. *Conf. with para. 35.*

No Limit to Yielding Capacity. *Conf. with paras. 214, 225.*

275. But there is a still further view of this subject of depreciation, that I desire to bring forward as deserving of careful investigation. Apart from changes in plucking and pruning, having altered the yield, I am satisfied that it would not be difficult to establish a steady decline in production with age as well as a concomitant depreciation in the quality of the tea produced.*

Decline in Quantity and Quality.

A letter which I recently issued on this subject was, I regret to say, construed by most of the persons who favoured me with replies, as having reference to the general fall in the sterling value of tea. The writers accordingly plunged into the vexed question of the benefit

Tea in Relation to Silver.

* A member of one of the most influential Calcutta tea agents writes me "Generally speaking, our experience has been that young gardens make the best tea."

DETERIORATION.

Comparative Values of the Teas of Old and New Gardens.

Old Gardens More Liable to Blights.

or otherwise to the tea industry of the depreciation of the rupee. But what I desired to arrive at was the comparative values of the teas of old and new gardens. It is necessary that the enquiry which I should like to see instituted, should be conducted in gardens where uniformity of pruning and plucking prevail, so that no error might be introduced on these points. Given an old portion of such a garden, can it be shown that it has preserved its value, alongside of new extensions both as to total yield and value obtained for its teas? I feel certain from the little experience I have already obtained, that the answer must be, that the old gardens have been giving for years back unmistakeable indications of a comparative decline in both quantity and quality. I am abundantly satisfied on one point, *viz.*, that old gardens are very much more liable to diseases and blights, than new ones. In some respects of course the decline in both quantity and quality might be said to be due to disease, though I should prefer to reverse the position and say that the natural decline, due to age or exhaustion, is the most potent of predispositions to disease.

Increase of Disease with Quality Plucking.

Uprooting Old Plantations. *Conf. with paras. 70, 77, 142, 164, 211, 225, 286-1.*

Danger of Indifference. *Conf. with para. 36.*

276. But I am asked,—What proof have you that the modern system of plucking for quality is acting injuriously? The growth of disease has been coincident very largely with the introduction of the new system, and the effects of both the pruning and plucking of the plant are so self-evident, in the one system as compared with the other, that argument to me seems superfluous. What then would you have us do is the question that is showered upon me by a large circle of planter friends. It is useless to tell us to apply for the permission to uproot old gardens that have for half a century given a steady profit and give even now, in spite of diseases and blights, something more than a competency. But I reply that was the answer put forward by the coffee planters of Ceylon when attention was first directed to the fungus that ultimately ruined their industry. It had been with them for years, did no doubt a little harm but what of that, their gardens paid good dividends in spite of blights.

Systematic Renewal of Stock.

277. Has it, however, been proved or disproved that systematic renewal of stock might not only be possible but even more remunerative than the present system? That is one of the problems that the practical man can alone determine. It is useless to discuss opinions for or against so radical a departure from established usage. What is wanted is a little practical experiment performed here and there all

over the tea area, so as to avoid every possible cause of error. Let a plot of land, admittedly bad both from blights and overwork, if possible 40 years old, be divided into three sections. One third (A) prune and pluck in exactly the same way as has been pursued for the past 30 or, it may be, 50 years : the second third (B) collar prune in the way I have recommended, *viz.*, just below ground ; and the last third (C) uproot, deep trench the ground to get rid of roots, sub-soil drain and manure freely, then plant out as if for a new clearance. There will, of course, be a heavy expenditure incurred on (C) and no return for possibly 4 years. The debit and credit account of each plot must, therefore, be carefully preserved for it is the results of 15 years from date of experiment that must be held as finally determining whether or not systematic renewal of a certain annual percentage of every estate, should not become an accepted system in successful tea planting. Collar pruning, at one stage, will give temporarily a new life to a garden no doubt, but there is a point ultimately attained, in which even collar pruning becomes unavailing, and the tea has then to be abandoned or cultivated at a loss.

DETERIORATION.

Practical Experiment Necessary.

Record Preserved for 15 Years.

278. I am of course judging purely and simply as a non-professional observer and have only scientific theories to guide me, but I should be very much astonished if (C) did not far outstrip either of the other two plots in its average annual profits for the term of years indicated. But I am asked,—Why not expend the sum required for renewal in opening out new extensions? Because, you have forgotten to put your factory on wheels and will not abandon the cultivation of old gardens even when you have got large new extensions. Good tea land is becoming scarce even in Assam. Large and valuable estates with expensive factories and bungalows, good roads, strong bridges, convenient markets and facilities of export, and many other such considerations, cannot be abandoned, because the land is either becoming less productive or the plant more liable to disease. Steps must be taken to ward off these evil consequences.

New extensions *versus* Improvement of Existing Estates.

279. The planter, in my opinion, will have to face in the future even more radical reforms, in his outdoor operations, than he has brought about within the factory. Nothing could be more admirable (though doubtless much still remains to be discovered) than the progress that has been made in the manufacture of tea. Little or no attention has been given to reforms in cultivation.

Reforms in Cultivation Essential.

Plucking.

DETERIORATION. **Uprooting and Replanting.**

280. Uprooting and replanting will, I venture to think, be much more generally practised ten years hence than most planters may at present be willing to admit. To increase or even maintain the yield at present demanded, improvements must be brought about in the productive capabilities of the stock; more rational and thorough systems of cultivation introduced; reforms effected in both pruning and plucking with a view to obtaining the maximum outturn with minimum injury to the plant; and lastly diseases, pests and blights, must be methodically studied and their eradication rendered possible through the discovery of the stages in their life histories at which they are likely to yield to systematic treatment.

Directions of Reforms. *Conf. with para. 70.*

Study of Health of Plant.

281. That there is a decline both in quantity and quality accompanying exhaustion and disease, I have no hesitation in believing, and I would, therefore, strongly recommend that in plucking as in pruning, everything should be done to study the health of the plant. No one, for example, seems to have grasped the idea that quantity plucking might easily be combined with quality improvement. That the plant is likely to be healthier when plucked for quantity I trust I have already abundantly demonstrated. Why not, therefore, improve quality by selection of stock or by special manures for that purpose? There are surely other methods of obtaining special flavours than the exhausting process of plucking off the leaves and shoots as rapidly as they appear. If that, indeed, be the only method then I repeat uprooting and replanting must become an accepted principle in tea-planting since diseases and blights are likely to increase instead of decreasing under the present systems of cultivation.

Improvement by Selection of Stock.

Uprooting. *Conf. with paras. 35, 70, 77, 142, 164, 211, 225, 276.*

Causes of Increased Production.

It is not the purpose of this report to deal with the statistical aspects of the tea-planting industry. No doubt, however, a study of the returns of area and production would reveal the fact that within recent years the latter had increased at a higher ratio than the former. That fact may be said to be due to the following among other considerations :—

(*a*) New systems of plucking:
(*b*) Relative increase of area under indigenous stock :
(*c*) Rapidity of expansion into new areas and thus high percentage of young gardens.

GENERAL PRINCIPLES

CHAPTER IX.

TEA FERTILISERS.

XLIII.—General Principles of Manures and Manuring.

282. Mr. David Hooper, Curator, (Economic and Art Section), Indian Museum, has written for me the interesting chapter that follows on Tea Fertilisers.

"I have had the pleasure to read the proofs of the foregoing chapters of this report, and concur most fully with Dr. Watt in the contention that imperfect methods of cultivation, more especially deficient or unsuitable food supplies, must act as predisposing conditions to disease. Just as ill-fed children are more liable to disease than those well nourished, it is only natural to extend the simile to the vegetable kingdom.

Predisposition to Disease. *Conf. with paras. 30, 47, 99, 226.*

"After what has already been said, in the foregoing chapters, it will not be necessary to dwell with any degree of detail on the food of plants, nor the various physical conditions of the soils, nor yet even to enlarge on all the elementary substances which constitute the soil and the plant organism, but only to refer to the chief sources of nourishment and the methods by which they can be utilised.

Plant Life. *Conf. with paras. 55-70.*

"I shall, therefore, direct attention chiefly to four important elements connected with the artificial improvement of the soil, *viz.*, potash, phosphoric acid, lime, and, lastly, the various offices which nitrogen fills in maintaining plants in a vigorous state.

283. "***Potash.***—When the various parts of a tea bush are burnt to ashes it will be found that the amount of ash is greatest in the leaves, least in the roots, and intermediate in the stems and branches. On submitting these ashes to analysis it is proved that the chief ingredient of the ash, from whatever part of the plant it is obtained, is potash. The ash of prepared tea is composed on the average of 40 per cent. of potash. These facts show the great importance of having this alkaline substance in the soil in which tea is grown. Potash is derived from the decomposition of rocks, chiefly of a felspathic nature, where it is combined as a double silicate of potash or soda and alumina. It is also present in an insoluble condition in the soil, but on account of cultivation in which it is exposed to the heat of the sun, the oxidation of the air, and moisture of the rain and dew it is liberated

Potash.

Composition of Soils. *Conf. with paras. 112-16.*

Tillage. *Conf. with paras. 54, 93, 155.*

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in a soluble combination. The soluble potash is very readily used up by the plant so much so that it is only in rich soils that potash is detected in the water extract. If an appreciable quantity of potash were dissolved out of an arable soil, the fact would constitute a test of the richness of the land. If, on the contrary, nothing soluble was obtained the soil could not be regarded as poor, though potash might be present in an insoluble combination.

Phosphoric Acid. *Conf. with para. 35.*

284. "***Phosphoric Acid*** is a very important constituent of the ash of tea, it comes next to potash in valuing the mineral constituents of the leaves, and is absolutely necessary for the tea plant. It is present in all seeds and is concerned in the formation of albuminous or nitrogenous matters in the growing part of plants. Phosphoric acid is present in nearly all tea soils in the insoluble forms of phosphate of iron, calcium or magnesium. The insoluble phosphates are dissolved by the carbonic acid of the air, or by the vegetable acids present in the humus before it is conveyed to the plant. A fertile soil contains from ·1 to ·2 per cent. or more of phosphoric acid ($P_2 O_5$), although it has been found that with as little as ·03 per cent. it is rich enough for cultivating purposes. Tea soils often require a tonic in the form of phosphatic manures, and as they are slow in their action, (unless rendered soluble by chemical means), they should be applied some time before they are actually required.

"The following are some of the more important phosphatic manures together with figures showing the percentage of phosphoric acid contained in them :—

Bone-ash . .	33-40	Guano . . .	15-30
Bone-black . .	26-28	Superphosphate .	12-15
Bone-dust . .	24-26	Wood-ashes . .	7-15
Mineral Phosphate .	25-40	Fish . . .	6-8·5

Lime. *Conf. with remarks.—Crole Tea Text-Book, page 102.*

285. "***Lime*** is another important constituent of the tea plant. It is present in the ash to the extent of about 15 per cent. or more, when below this amount its place is taken by magnesia which is frequently associated with lime both in the leaf and the soil. It is present in all tea soils, although in many Assam samples it occurs in traces only. Lime is found naturally as carbonate, sulphate or phosphate; as sulphate it is soluble in water, and in the other forms it is rendered soluble by the agency of carbonic acid. On account of its mechanical properties, it is very useful in mellowing clays and in increasing the

retentive power of sandy soils. It acts upon organic and inorganic matter by hastening the decomposition, and counteracts the sourness of humus; it assists in the formation of nitrates in the process of nitrification of soils, and combines with the newly formed nitric acid. To modify the action of lime when applied to the soil, it should be followed by a liberal dressing of decaying vegetable matter. In the recent experiments in the assimilation of nitrogen by means of root tubercles the presence of lime has been regarded as indispensable. In the tea plant lime is employed to build up the cells of the various organs, and contributes to the vigour of their growth. In view of the many uses of lime in the vegetable economy the remark made in one of the most recent publications on tea that 'tea can subsist practically without the presence of lime' shows how dangerous it would be to follow wild assertions and to depart from some of the simplest rules of scientific cultivation.

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Sandy Soils. *Conf. with paras. 96, 113, 157, 291.*

Root-Tubercles. *Conf. with paras. 69, 93, 109, 116, 165, 297-313.*

286. "A curious observation is made in the *Tea Cyclopædia* to the effect that the Chinese have been said to import the shells of shrimps—a calcareous substance—as a manure for the tea plant. They said it was the only remedy known in that country for tea pests.

287. "***Nitrogen.***—The opinions as to the value of nitrogen are to be regarded with great caution, and must be studied from a practical point of view. We are told by some that the luxuriant growth of tea is in direct ratio to the nitrogen present in the soil, while others find that nitrogen is a variable quantity and is not so reliable an indication of the fertility of a soil as other ingredients. There is no doubt about it being an essential food for tea as it is for all other vegetation, and to conserve it in the soil should be one of the chief objects in cultivation. The action of the air as an oxidiser is so great that it is conceivable that under a hot sun soils left unworked and without manure may gradually become sterile owing to the disappearance of nitrogenous humus. In the form of ammonium nitrate, nitrogen is brought to the soil by the rain, but not in sufficient quantity to replace the whole of this element removed annually from the tea bushes by plucking and pruning.

Nitrogen. *Conf. with paras. 69, 109, 296.*

Action of the Sun. *Conf. with paras. 107, 288.*

288. "***Humus.***—The humus or organic matter is the chief source of nitrogen in the soil. Hilgard has shown that with reference to 'nitrogen hunger,' a term used for denoting the absence of nitrogen in a soil, the humus should be separated and examined. The carbonaceous and nitrogenous matters should be well balanced, if

Humus. *Conf. with paras. 93, 109, 155.*

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the albuminous matter preponderates, less carbon will be oxidised by the limited amount of oxygen in the soil; and if the humus contains less than 2·5 per cent. of nitrogen, it would be benefitted by the addition of nitrogenous manure notwithstanding the soil itself containing as much as 0·17 per cent. of nitrogen. It is a very simple matter to calculate the proportion of nitrogen in an analysis. The humus is returned as organic matter and combined water, and if the percentage is worked out it will almost invariably be found that the nitrogen forms 5 to 10 parts or more in 100 parts of humus. In some tables before me the humus of an exhausted tea soil in Assam is shown to contain 1·8 per cent., and that from virgin soil 4·2 per cent. of nitrogen. But here it must be remarked that the consideration of one element is not infallible; for instance, it has been proved that a soil may be rich in nitrogen, yet if there is a deficiency of lime the soil would indicate nitrogen hunger.

Proportion of Nitrogen in Humus.

"As the organic matter becomes exhausted by slow decomposition and only a portion of it finds its way to the plant, the soil will require careful attention. The loss of nitrogen by the crop on the one hand, and its partial replacement by the agency of the rain, the decomposition of humus, and the absorption by certain organisms on the other, point to an unequal combination of circumstances which must eventually rob the tea plant of its food. As long as the crop shows no decrease in quantity, planters have considered manures unnecessary, and think it will be time enough to resort to such measures when the plants look unhealthy.

Loss of Nitrogen.

XLIV.—Manures for Tea.

289. "Having touched upon the most essential chemical elements of the tea plant, and before alluding to the subject of green manure and the new researches on nitrogen in the soil, it will be necessary to refer to a suitable manure for exhausted tea gardens where, owing to their weak state, the plants are unable to resist the attacks of blight.

Weakened Plants Liable to Blights.

"The following analysis of the ash of tea leaves by Mr. John Cripps may be taken as a type of the composition. It agrees in some details with the results shown by Messrs. Wanklyn, Zoller, Hodges and Hughes, except for the appreciable quantities of sulphuric acid and a larger amount of lime found by other analysts.

"The first column shows the composition of the ash in 100 parts, and the seeond column gives the amounts of the several ingredients

MANURE for TEA.

calculated as yielded by the tea leaves, the total ash of which may be taken at 6 per cent.—

Composition of Tea Ashes.

Potash	39·22	2·35
Soda	·65	·04
Magnesia	6·47	·39
Lime	4·24	·26
Iron oxide	4·38	·26
Manganese oxide	1·03	·06
Phosphoric acid	14·55	·87
Chlorine	·81	·05
Sulphuric acid	trace	...
Silica	4·35	·26
Carbonic acid	24·30	1·46
	100·00	6·00
Nitrogen (average)		4·00

Materials Removed from the Soil. *Conf. with para. 270.*

" A crop of made tea consisting of 500lb per acre (*Conf. para.* 239) would remove, according to the above analysis, 11¾lb of potash, 4⅓lb of phosphoric acid, 1⅓lb of lime, and 20lb of nitrogen per acre.

" In attempting to return to the soil in the form of manure all the fertilising constituents abstracted by the plant it must be borne in mind that it is impossible to calculate the composition of a manure so as to represent the exact proportion of plant food necessary. The ash of the tea leaves, for instance, does not give an absolute indication of the loss, as the prunings with a larger percentage of lime have to be taken into account, the available nitrogen and salts and their combinations must be known, and it should be remembered that the several parts of a manure are not absorbed by the roots with equal velocity.

A Manure for Tea.

290. "***A Manure for Tea.***—Considering that there are four elements eminently necessary for the tea plant, the following mineral mixture would supply a very suitable manure. The potash salts would first be assimilated because of their ready solubility, while the phosphates would require the action of the soil and carbonic acid to make them sufficiently soluble :—

Mineral phosphate (containing 60 per cent. of tricalcic phosphate).	50	Lime	16
		Phosphoric acid	14
Saltpetre (95 per cent.)	30	Potash	13·3
		Nitrogen (in nitrate)	3·9
Ashes (of wood or plants)	20	Potash	2
		Phosphoric acid	1
		Lime	1

Tea Fertilisers.

GREEN MANURING.

"A manure of this description could readily be prepared in India. A mineral phosphate of the above composition is afforded by the deposits of nodules near Trichinopoly. If mineral phosphate is not procurable in Northern India, bone-dust, an article which would supply additional nitrogen or ammonia, might be substituted. If more nitrogen is required, the ashes might be replaced by one of the many oil-cakes obtainable at a cheap rate wherever oil-seeds are cultivated and pressed.

GREEN MANURING. *Conf. with paras. 95, 108-9, 170, 267.*

XLV.—Green Manuring.

291. "An application of green leaves or herbaceous plants, to regenerate the soil has been resorted to from time immemorial both in wet and dry cultivation. There can be no doubt that it is one of the most economical manures and a very convenient source of nitrogen. But for the leaves to be of advantage to the land there should be a deficiency in organic matter in the soil, and lime, potash and phosphoric acid must be present, as the mineral matter in green manure is not rendered available for use until decomposition is far advanced. It is usually applied by allowing a herbaceous crop to grow nearly to maturity, and then ploughing or hoeing it into the earth. At other times certain plants which are empirically known to improve cultivation are brought from a distance and worked into the soil. The leaves that fall from the shade trees planted in an estate, contribute no doubt to the more valuable constituents of the soil, although their action may vary according to their chemical composition and the time of year when they are shed. Green manure renders the soil porous, and is more especially suited for exhausted sandy loams.

Conf. with paras. 96, 113, 157.

292. "The following information concerning materials of this description which have been used either experimentally by European planters or for ages by the ryots, will serve as a guide to their value.

Acacia.

"The **Acacia dealbata,** or Yellow Wattle, is a leguminous tree introduced on the Nilgiris, the tops of which have been tried as a source of fertility to coffee and tea soils. It is richer in nitrogen than cattle manure, and is very abundant near tea estates. **Tephrosia purpurea,** a leguminous shrub related to the indigo, is used by native cultivators in Tinnevelly, who buy it by the cart load, and consider the leafy branches of great value for their crops. **Erythrina lithosperma** is the 'Dadap' of Java. It has been introduced into some

Tephrosia. *Conf. with para. 312.*

Erythrina.

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estates as a shade and has been recommended for its manurial properties. The roots are provided with nodules similar to those of other nitrogen gatherers of this order, and the fallen leaves are said to benefit the soil, and ultimately the plants, growing near the trees. **Desmodium gangeticum**, a leguminous herb, has also been tried as a green manure in Southern India. The large leaves known in Tamil as *watta-gunie* (**Macaranga Roxburghii**) have been used for centuries by the natives all over Mysore and Travancore for improving their rice crops. The tree is found near tea estates, and a sample of the fallen leaves was sent to me for valuation. The *watta-gunie* belongs to the natural order EUPHORBIACEÆ. The above four plants were supplied by Mr. E. M. Ewart, of Shencotta, who advocates green manuring very extensively. The table below gives the analyses of these plants as also of **Adhatoda Vasica**. The remarkable manurial value of that plant is appreciated by the agriculturists of Northern India.

Desmodium.

Macaranga.

Adhatoda.

Conf. with Hand-Book recently published.

Analyses.

293. "The following analyses show the uniformity of the nitrogen in the first three leguminous plants and the variation in the amount and constitution of the mineral matter. The results are calculated on the absolutely dry plants :—

	Acacia dealbata.	Tephrosia purpurea.	Erythrina lithosperma.	Desmodium gangeticum.	Macaranga Roxburghii.	Adhatoda Vasica.
Albuminoids .	17·64	17·51	17·45	20·16	15·23	23·43
Fat . .	3·80	7·03	2·60	5·66	9·65	5·82
N.-free extract	49·18	40·36	29·31	14·50	23·41	18·87
Crude fibre .	25·55	28·39	43·35	49·38	44·94	30·28
Ash . .	3·83	6·71	7·29	10·30	6·77	21·60
	100·	100·	100·	100·	100·	100·
Nitrogen .	2·80	2·78	2·77	3·20	2·41	3·72
In 100 parts of ash.						
Potash . .	13·84	23·23	35·14	18·64	14·11	20·11
Lime . .	26·32	18·63	9·14	20·68	14·22	...
Phosphoric acid	5·13	5·89	8·41	3·40	6·31	...
Silica . .	6·59	2·23	2·44	13·59	24·28	1·86

Value of weeds to the Soil.

Conf. with paras. 95, 99, 109-118.

294. "*It has been noticed in California that trees give a decreased* production of fruit when the orchards are constantly weeded and the soil deteriorates physically notwithstanding the application of manures. Mr. E. Hilgard in 1896 used the square pod pea (**Lotus Tetragonolobus**), as a green manure to supply the nitrogen to the soil.

The plant was most suitable; it yielded 24-26 tons per acre. T nitrogen percentage is less than that of lucerne or clover, but nitrogen of the produce of an acre is much larger.

295. "In Assam the manuring of tea is usually practised in cold weather. Some good results have, however, been obtained w manure applied later, and some planters have advocated June the best month when the land is moist with the early showers. Mr. G. Stoker, of Cachar, recommends weed and grass mulching a capital method for improving the surface soil. For the sides of *lahs* and exposed western slopes mulching is perhaps the best pl that can be adopted. It has been found that 800 maunds of mixture of green weeds with cowdung hoed into an acre during t rains has given excellent growth and has doubled the yield of tea.

XLVI.—Nitrification.

Chemical Combinations of Nitrogen.

Conf. with paras. 56, 58, 62, 109, 287.

296. "The nitrogen in the organic matter or humus of the soil for the most part in an insoluble condition and not available for t food of the plant. The oxygen of the air acts upon the vegetal albumen and produces ammonia the odour of which is always notic able in stables and in pits where vegetables are allowed to rot. T ammonia combining with certain acids forms soluble and neutral sa which are readily absorbed by the roots. The whole of the ammor is not disposed of in this manner; a portion is attacked by a minu organism or ferment which changes it into nitrous acid, and anoth organism acting upon the nitrous acid changes it into nitric ac This process of converting ammonia into nitric acid is a process oxidation and is carried out in two stages by two distinct forms bacteria which are recognisable under the microscope. The lit organisms are termed nitrifying bacteria and the whole process known as nitrification. Nitrification is a most important part of natu fertilisation and is more or less actively going on in all soils. T effects of nitrification are seen in the saltpetre deposits near aba doned villages in India, and in the dry regions of Chili and Peru su vast accumulations of sodium nitrate are found that thousands tons are exported annually to the United Kingdom and the contine

XLVII.—The Fixation of Nitrogen by Plants.

Conf. with paras. 62, 109.

297. "The method of assimilating nitrogen from the atmosphe

by means of root tubercles should be clearly distinguished from the process of nitrification which has just been described. The reader will find much useful information on this subject in an issue of *The Agricultural Ledger* No. 7 of 1894. The present remarks are indeed intended to amplify that paper in one or two directions, more especially in giving an explanation of the well-known properties of the *sau* tree (**Albizzia stipulata**). The question whether free nitrogen can be taken up by plants has been a source of discussion among scientific agriculturists for many years. It was accepted, as a rule, that this element could not be used by the plant except in combination in the form of humus, manures, and rain-water. **Messrs. Lawes and Gilbert**, however, in the course of their experiments on crops, found that leguminous plants, such as vetches, beans and peas, contained more ntirogen than could be accounted for by the ammonia and nitric acid supplied in manures and rain-water. In addition to this fact it should be mentioned that it has been known for hundreds of years that the fertility of the soil could be improved by the growth of leguminous crops in rotation with other crops.

FIXATION of NITROGEN.

Sau Tree. Conf. with paras. 11, 86, 110, 302-3, 311.

298. "In 1886 **Hellriegel** and **Wilforth**, after working for three years on the subject of direct nitrogen assimilation by plants, discovered that many of the PAPILIONACEÆ (a sub-order of the LEGUMINOSÆ), obtained a large proportion of their nitrogen from the atmosphere. The excess of nitrogen was due to certain micro-organisms that flourished in and around the roots of these plants which assimilated the gas and rendered it available for the plant. In the absence of these organisms the fixation of free atmospheric nitrogen did not take place. Having found that nitrogen was absorbed from the air by these organisms, the German chemists determined to test whether the nodules or tubercles on the roots were in any way connected with the nutrition of the plants. These tuberosities never appear in sterile soil, and are always associated with luxuriant growth. On cutting them open and examining them microscopically, they are seen to contain amongst their cells a ramifying growth which in time gives rise to a number of small cells having much the appearance of bacteria, and called by some investigators **Bacterium radicicola.** The nodules contain a large quantity of nitrogen, but the quantity appears to vary according to the development of the plant upon which they grow. **Stoklasa** in 1895 examined

Hellriegel and Wilforth's Discovery.

FIXATION of NITROGEN.

Nodules of Yellow Lupin.

the roots and nodules of the yellow lupin and found the following percentage of nitrogen present:—

	In Roots.	In Nodules.
Flowering period . . .	1·64	5·22
Fruiting period . . .	1·84	2·61
Complete ripeness . . .	1·42	1·71

299. "The manner in which the nitrogen is used by leguminous plants is not perfectly understood, but it is generally supposed that the bacteria present in the tubercles feed upon the nitrogen, and the foster plant feeds upon the bacteria. Others maintain that the bacteria give rise to degenerate forms called bacteroids which are the indispensable factors in nourishing the plant.

Prazmowski's Conclusions.

Prazmowski has summarised the conclusions arrived at thus:—

1. The root nodules are symbiotic* formations, which derive benefit from the plants by obtaining nourishment from them, and are thus enabled to propagate themselves, and on the death of the plant to return in greatly increased numbers to the soil.
2. The symbiosis is of use to the plant by enabling it, under the influence of the bacteria, to feed on atmospheric elementary nitrogen.
3. Only plants provided with nodules can acquire nitrogen from the free nitrogen of the air.
4. The recovery of the infected plant and the emptying of the oldest nodules are coincident.
5. The absorption of the bacteroids is the means by which the plants obtain atmospheric nitrogen.
6. It is probable that the bacteria are built up of starch and elementary nitrogen.
7. In the absence of other sources, the nodule-bacteria are able to assimilate free nitrogen, although to a much less extent than when in symbiosis with the plant.

300. "It was at first supposed that nodule-bearing plants were confined to the Papilionaceæ, and that no other family had the power of absorbing nitrogen from the air. Recent experiments, however,

* A term that may be defined as the living together of dissimilar organisms.—*G. W.*

have shown that that phenomenon is not the peculiar property of the pulse-bearing plants. The ALGÆ, for instance, have the power of fixing free nitrogen, and it is impossible to say at present to what extent these lower organised plants are concerned in supplying nitrogen to the higher forms of vegetation. **FIXATION of NITROGEN.**

301. " **Nobbe** has found that a flowering tree, the **Elæagnus hortensis,** far removed from the LEGUMINOSÆ, has tubercles on its roots and is able to fix free nitrogen. **Hiltner** in 1895 made the interesting discovery that the roots of the alder (**Alnus glutinosa**) if provided with nodules, utilise nitrogen in a similar manner as the PAPILIONACEÆ. It was noticed that the organisms that produce nodules in the alder root act as a parasite until the nodule is fully developed, after which the plant benefits. A comparison between analyses of the alder nodules and those of the lupin reveal a great difference in the amount of combined nitrogen present in the form of proteids. **Elæagnus Nodules.** **Alder Nodules.**

Roots of Alder	.	5·4	per cent. of protein.
Nodules " "	.	8·3	" " "
Roots of Lupin	.	5·2	" " "
Nodules " "	.	31·6	" " "

"The alder appears to a disadvantage when compared with the lupin, but the appearance of nodules on its roots is an interesting observation. In this connection attention may be drawn to the fact that the alder leaves contain more nitrogen (3·61 per cent.) than the leaves of many of the common forest trees of Europe as shown by their examination by **Professor Emmering** about 12 years ago.

302. " Regarding the plants outside the PAPILIONACEÆ which develop root nodules, reference must be made to the leguminous shade trees used in tea plantations, a subject which brings us to a practical consideration of the supply of nitrogen to the tea plant.

" Several years ago **Colonel Hannay** (in Dibrugarh, Assam) called attention to the value of the *sau* tree and gave it the name of the tea fertilising tree. The *sau* tree is **Albizzia stipulata** of botanists, and belongs to the sub-order MIMOSEÆ of the LEGUMINOSÆ. To **Mr. J. Buckingham** belongs the honour of having prominently drawn attention to the value of the *sau* tree. Several experiments were made by him which went to prove that *sau* possessed peculiar properties in bringing round exhausted soils and causing the bushes to **The *Sau* Tree in Tea Gardens.**

FIXATION of NITROGEN.

flush vigorously, while imparting a vitality of which old tea was deficient. On the 23rd October 1884, Mr. Buckingham published, for the benefit of the Indian Tea Association, a little pamphlet on this subject which gave his own experience and that of several planters regarding the *sau* tree. Shade is not usually the cause of an increase of yield, and is in fact condemned by the generality of planters, as it tends to make the bush throw out long stalky shoots and thus to produce poor and woody flushes; such, however, can hardly be said to be the case when *sau* is employed. The tea bushes under that tree have been reported by those who believe in it to yield a considerably higher amount in a given area than in any other part of the garden, under similar conditions of soil and age of bush. It has been observed that tea grown under *sau* enjoys a considerable immunity from blights and pests, while the surrounding trees are suffering badly.

The Influence of the *Sau* Tree.

"The action of the *sau* was attributed by some to the beneficial shade which it casts over the plants; others considered that it was the manure furnished by the dead leaves; a few thought that the advantage of interplanting the trees was the fact that the roots went to a greater depth than the tea roots, and drained the superabundant moisture from the surface soil, while, on the other hand, they brought up from the sub-soil food material for the tea plants. Mr. Buckingham remarks, 'I do not wish to contend that *sau* is capable of improving tea plants where the soil contains elements which in some instances nature has abundantly supplied for the support of the bush, but I do assert that the vitality of the tea bush is limited probably in a great measure depending on the character of the soil, and unless we restore some of those essential parts we are yearly, I may say weekly, abstracting, the tea-planter in a few more years may be surrounded by tea which the very best cultivation and the most scientific pruning can never bring round.'

Nodules on Albizzia Roots.

303. "The immediate benefit which Albizzia confers upon the soil and the tea plants where it grows is not due to some chemical ingredient imparted to the soil, as was once supposed, but to the presence of tubercles which are attached to the roots. The discovery of these tubercular bodies on the roots of the *sau* tree was made by Dr. Watt during his tour in Assam in 1895. Dr. Watt not only noticed the prevalence of the nodules but, by examination under the microscope, he was able to detect the bacteria in the cells of these structures.

This then is another instance that the fixation of nitrogen by means of nodule-bacteria is not confined solely to plants of the Papilionaceæ. Since this discovery Dr. Watt has found that the Sensitive Plant (**Mimosa pudica**), the *babúl* tree (**Acacia arabica**), and many other species of the Mimoseæ possess nodules, but that so far none of the Cæsalpinieæ have been found to do so. **FIXATION of NITROGEN.** **Nodules in the Mimoseæ.**

304. "The comparative absence of blights in the vicinity of trees of this order is a very important point in connection with successful tea cultivation. The action of nitrogen in the soil may not interest some planters, but when they see the pests of their gardens kept off by certain trees, which serve a double purpose of fertilising the surrounding land, the subject becomes one of no mean importance.

305. "In Dr. Watt's diary (kept during his tour in Assam), reference is made to another legume-bearing bush which may be here mentioned. 'I was taken,' he writes, 'to a discontinued portion of the garden where I found a species of **Dalbergia** (*medeloa*). Around these trees, tea was seen in large healthy clumps of dark green bushes, while between these clumps the plants that formerly existed had all died, or were small and sickly. By my direction certain seedlings of the **Dalbergia** were dug up, and on subsequent microscopic examination these were discovered to contain a **Bacterium** in their root tubercles. It was, moreover, recorded as remarkable that in the deserted garden no blights could be seen except two or three bushes with thread blight, one in a particularly vigourous clump right under a **Dalbergia.** I next inspected the hilly portions of the estate where the tea yields so little that the terraces are only hoed once a year. The bushes were mostly China or poor hybrid and in bad condition. Blights were prevalent except under and around a semi-scandent **Dalbergia** where they were large and healthy-looking. It thus seemed a matter that placed beyond doubt that leguminous trees were beneficial to the tea and, to a certain extent, gave immunity from disease.' **Advantages Derived from Dalbergia.**

306. "In another district Dr. Watt had occasion to visit a garden where *medeloa* (**Dalbergia assamica**) trees had formerly been planted. 'The tea was one of the finest bits in the garden, large, well-formed plants of a deep green colour, flushing freely. As the *medeloa* belongs to the Papilionaceæ it had enriched the soil and the tea was reaping the benefit for years after the *medeloa* bushes had been felled.'

SOIL INOCULATION.

XLVIII.—Soil Inoculation.

307. "The other method of bringing nitrogen to the crop besides that of directly applying nitrogenous manures is by inoculation of the soil with bacteria. In the process of assimilating nitrogen by the agency of nodules on the roots of leguminous and other plants, the nodules yield up to the soil myriads of bacteria. These bacteria live normally in the soil, but are especially abundant in soils where leguminous crops have grown; they fix upon the roots of certain plants, absorb nitrogen for their benefit and are after certain changes consumed by the plant. The absence of nitrogen-bearing bacteria from the soil gives rise to 'nitrogen hunger' in the plants and this is known by the unhealthy appearance, slow growth and the lighter colour of the leaves. The presence of these bacteria under normal conditions increases the vigour and development of the plant, improves the flower and fruit production, and prolongs the vegetating period. The experiments of Nobbe and Hiltner in 1896 would seem to show that inoculation with nodule-bacteria is effective in plants of a similar kind. Thus in the LEGUMINOSÆ the bacteria of the pea (**Pisum**) was not used up by the vetch (**Vicia**), the bacteria from the kidney-bean (**Phaseolus**) nodules were not rendered available for the **Robinia**, and the inoculation of lucerne (**Medicago sativa**) with clover-bacteria had scarcely any effect. The bacteria used for inoculation, if a successful result is to be expected, must correspond with the plant, and the best results are obtained by using the organisms of a particular plant, as **Robinia** for the inoculation of that species.

Inoculation Experiments.

The soil may be inoculated in two ways:—*1st*, by broadcasting some hundredweights of earth taken from land that has yielded a good leguminous crop. *2nd*, by watering the field with water which has been in contact with earth from land which has yielded a good leguminous crop. (For further information on soil inoculation, see an article on "Green Manuring" in *Journal of the Board of Agriculture* for June 1897.)

308. "A preparation in the form of a gelatine cultivation has recently been made in Germany which under the name of nitragin is said to supply the peculiar bacteria for leguminous crops. The inoculation of the soil by this article is very simple. The liquified medium is diluted with sufficient water to moisten the seeds, or it is mixed with dry earth which is scattered over the field. As the pre-

Artificial Inoculation.

paration has to be kept in the dark and must not be heated above the temperature of the human body, it is not likely to be used with much success in India.

SOIL INOCULATION.

Practical Application.

309. "Dr. Watt has made the practical suggestion, however, that instead of the use of highly cultivated media and soil infusions, the soil itself in which a leguminous crop has been grown should be distributed broadcast over plantations where nitrogen hunger is observed. The proposal is as follows—'500 acres should be divided into five or ten plots each in rotation to be sown with *matti-kalai* (Phaseolus aconitifolius) or other leguminous crop. After the legume is grown and ripened hoe in the green stem and leave the plot of land till complete decomposition has taken place. The soil will then be highly charged with bacteria and by scattering it in handfuls all over the estate the soil will be inoculated with nitrogen-forming organisms.'

Matti-kalai. *Conf. with paras. 110, 312.*

310. "The above method is in keeping with the theory that, when a papilionaceous crop is grown mixed with a non-papilionaceous crop, the latter will possibly derive benefit from the nitrogen fixed by the former. In the case of cotton growing along with indigo or guinea grass with lucerne, it is likely that the non-leguminous plants receive benefit from their neighbours. It is hardly necessary to point out tubercles on the roots of plants as a means of distinguishing those that contain a large quantity of nitrogen from those that yield a small amount. Tea has never been observed to grow nodular formations, but it has been proved that the bushes are all the better for being reared near nitrogen formers.

Benefits of Nitrogen Inoculation.

"There are many points to be examined into in connection with the manuring of tea soils, in procuring the best fertilisers, in cultivating the best crops for green manuring, and in selecting the most suitable leguminous trees for avenues. The action of external agents in producing the tannin, or the alkaloid, or the flavour in the prepared tea-leaf is a domain upon the threshold of which science has scarcely entered. Careful experiment and patient and accurate observation are required to carry on the discoveries of others and to bring the cultivation of tea to a more satisfactory issue."

Tannin in Tea. *Conf. with paras. 263, 311.*

XLIX.—Concluding Remarks on Tea Fertilisers.

311. I have allowed Mr. Hooper's contribution to this report to appear in the form written by himself and have only exercised a slight editorial supervision. I have on several occasions suggested

TEA FERTILISERS.

that the study of tea manures should assume two forms, (*a*) those calculated to remove defects in the soil and thereby improve the health of the plant ; (*b*) those having a direct bearing on the improvement of the quality of the tea. Whether chemical research has advanced far enough to allow of the second consideration assuming a practical form, may be open to doubt. That manuring tea has become a pressing necessity, however, there can be little room for doubt. But the first and most urgent demand is to meet in some way the defect of there being no rotation of crops in the tea plantation. The value of certain leguminous plants, in the supply of nitrogen to the soil, cannot be too loudly proclaimed. Mr. Bamber in two or three isolated passages alludes to this subject, but it is so important and so obvious that I was surprised, on first reading his valuable work on the *Chemistry and Agriculture of Tea*, to find that he did not devote a special chapter to this subject. He apparently never thought of examining the roots of the *sau*, and thus could not have had any very definite conception of its aiding in the direction here more especially indicated. But it is not so much the presence of large *sau* trees in an estate that is beneficial as the fact that the thin pods of that tree are blown in the wind and the seed thus sown all over the estate. These spring up as self-sown seedlings only to be hoed in as green manure. They have lived long enough in the soil even then, however, to have become powerful agents in the supply of nitrogen. I am thus not by any means sure that we have even yet found a better plant than Mr. Buckingham's favourite—the *sau*. But I should strongly recommend that it should be treated as a green manure. The roadsides of all tea gardens might with advantage be planted with *sau* trees. It is, as I have already mentioned, commonly found in association with the truly wild tea plant. It has never been shown to be in any way injurious to the tea, and its shade is only temporary. A crop of seed might annually be obtained from the avenues and sown broadcast in selected plots of tea. When two feet or so high the crop could be hoed in as green manure. It would not, however, be necessary, nor practicable, that the whole of an estate should bear a crop of *sau* at one and the same time. Were each portion of the garden in rotation, every fifth or sixth year so treated, I have little doubt in affirming that a vast improvement would be brought about.

Manuring a Pressing Necessity.

Absence of Rotation of Crop.

Value of *Sau* Trees.

Shade Temporary.

Tea Fertilisers.

TEA FERTILISERS.

312. I have no faith in soil inoculation, so far as tea planting is concerned. But there are many more plants rich in root-warts besides the *sau*. The climbing and bushy species—**Dalbergia volubilis, D. assamica** and **D. stipulacea** (*medeloa*) are perhaps quite as good. Then again the sensitive plant has perhaps more root nodules than any other plant in Assam. Its thorns render it, however, impracticable except to sow on old nurseries and Assami village sterile plots. A crop of the sensitive plant would rapidly improve any land that there may be no occasion for coolies to walk over for some short time. The jungles of Assam contain many common species of leguminous plants such as **Crotalaria striata, Desmodium polycarpum, Tephrosia candida** and **Uraria crinita.** These would grow as weeds on the tea land if sown and left alone for a month or two. The coolies treading on them while collecting the tea, would not materially hurt them, as they are hardy plants, and the **Desmodium** mentioned is procumbent. Many planters have already acted on the suggestion to grow *mutti-kalai* (**Phaseolus aconitifolius**), the cultivation of which is fully understood by the coolies; that plant should, I think, prove of great value. One company has imported from England a supply of lupin seeds and raised a crop as a nitrogen giving green manure. I have not heard the result, but the yellow lupin (**Lupinus luteus**) has been long recognised in England and Germany as one of the best plants for this purpose.

Strips of Land for Leguminous Crops.

313. But I would here urge the suggestion already offered (paragraph 165) that strips of land should be left through every estate for ventilation purposes. Even if pipe drains be found impracticable or too expensive, these strips of land would be simply invaluable for the cultivation of nitrogen-giving plants, and an exchange of soil from these strips with the intervening plots of tea would, in my opinion, be perhaps the most economic and practicable method of securing the much-needed renewal of soil fertility. But it is enough for me to suggest the imperative necessity for this subject being taken into serious consideration. Difficulties are no doubt likely to be experienced, both in discovering the best plant and most convenient method of cultivation, but these and all such objections will instantly disappear when the subject is approached in the spirit of an earnest desire to secure the advantages indicated.

PESTS and BLIGHTS.

CHAPTER X.

THE TEA PESTS AND BLIGHTS.

L.—Introductory Observation.

314. As a matter of convenience I have accepted the word "Pest" to denote Insect and other Animal Enemies, and the word "Blight" to refer to Fungal and other vegetable Parasites of the Tea Plant. While convenient the restrictions indicated for these words are of course open to criticism.

Constitutional Diseases. *Conf. with paras. 26, 30, 45, 51, 92, 106, 166, 186, 197, 318, 320.*

315. In the preceding chapters I have endeavoured to represent certain aspects of the cultivation of the plant that seem to me to call for more careful investigation, with a view to reforms. To my mind there exists sufficient presumptive evidence to justify the opinion that certain misapprehensions and defective methods of procedure have originated constitutional weaknesses that may be said to constantly predispose the plant to actual disease. In other words to render the depredations of its enemies and parasites more alarming than they might be otherwise. I have, therefore, advocated that such reforms as may be found desirable and practicable, should necessarily accompany more specific efforts to battle with the pests and blights.

Predisposition to Pests. *Conf. with paras. 30, 47, 92, 226, 282, 320.*

316. In the foregoing remarks, at one or two places, I have already pointed out that the brief term of my explorations and the facilities of observation and investigation afforded, do not justify any attempt being made to deal with the pests and blights in a strictly scientific manner. It may be remarked that there are perhaps a dozen enemies of serious moment. The others, while occasionally doing considerable injury, are, nevertheless, of a local and accidental character. To solve the life histories of the dozen serious pests and blights, might take several years' patient study. To discover means of dealing with them, would occupy much time and necessitate detailed and elaborate experiments.

Scientific Report. *Conf. with paras. 2, 54, 55, 92.*

Experiment Indispensable. *Conf. with paras. 25, 108, 274, 277.*

LI.—Sources of Information and Assistance.

317. In presenting the observations which I now propose to offer it may be as well to explain the chief sources of information and assis-

tance which have been drawn upon in the study of the pests and blights of the tea plant:—

SOURCES of INFORMATION. General.

1st.—The Journals and Proceedings of the Agri.-Horticultural Society of India, more especially from 1865 to 1885—the period of greatest interest by the Society in the subject of Tea Pests.

2nd.—Special publications on the India Tea Industry, including the annual Reports of the Indian Tea Association from 1882 to 1896.

3rd.—Newspaper correspondence from 1873 to present date, more especially the letters which appeared originally in the *Tea Gazette*, but which may now be conveniently consulted in the *Tea Cyclopædia* and the *Tea Planter's Vade Mecum*. I have only incidentally referred to Ceylon newspapers for information, but the *Tropical Agriculturist* has been found of great value in confirming or correcting information regarding India.

4th.—*The Indian Museum Notes*, more especially **Mr. E. C. Cotes'** Account (*in Vol. III.*) of the *Insects and Mites which attack the Tea Plant in India*.

Botany.

5th.—The invaluable aid of **Mr. W. T. Thiselton Dyer,** Director of Kew Gardens, London, and of **Mr. George Massee,** Cryptogamic Botanist to the Herbarium of Kew, for two reports on certain fungal blights collected by me. Through the kindness of the Director General, Medical Department, I have been favoured with a proof copy of **Dr. D. D. Cunningham's** forthcoming paper "On Certain Diseases of Fungal and Algal origin affecting Economic Plants in India;" in that paper three of the diseases of the tea plant have been dealt with and consequently drawn upon very largely by me.

The liberal assistance of **Sir George King** and of **Dr. D. Prain** of the Botanical Gardens, Calcutta, for helping me with the determination of the plants collected during my tour in Assam. This every now and again has been of value in connection with the present report as, for example, in giving the names of the plants on which certain tea blights were found in the jungles.

Entomology.

The very great assistance, most generously afforded, by **Mr. E. E. Green,** the distinguished Entomologist of Ceylon, who has for many years identified himself with the study of the tea pests and has in consequence discovered and investigated the life histories of a large number of very obscure species. **Mr. Green** has not only examined and reported on a complete series of the insect

SOURCES of INFORMATION.

pests collected by me, but has in return presented a most valuable set of the pests collected by him in Ceylon. As types of the species he has named these have proved invaluable. Similarly I am much indebted to Dr. A. R. S. Anderson, Officiating Superintendent of the Indian Museum, for having examined the doubtful specimens referred by me to the Museum for determination, and to Mr. Edward Barlow, the Assistant in charge of the Entomological Collections of the Indian Museum, for having very kindly worked with me during the time which I spent in comparing my specimens with the Museum sets.

Co-operation of Planters. *Conf. with paras. 19, 24.*

6th.—But a debt of gratitude is more especially due to the large circle of planters whom it was my good fortune to meet during my tours and from whom I obtained much valuable assistance. Added to all these sources of information I may mention the files of correspondence of the office of Reporter on Economic Products which have been freely drawn upon and, lastly, the results of my own personal explorations.

History of Appearance.

318. The account to be given below, therefore, of each species of pest or blight will be made, as far as possible, to embrace the entire available information. Stress will be laid on the effort to trace out the locality and date of first appearance, of each of the more important enemies of the tea plant, from the belief that particulars of that nature may very possibly be found of value in future investigations. I am fully conscious, however, that defects will be discovered, and can only hope that the present review of information may stimulate greater attention being given, more especially through the planters themselves once more making the technical journals of the day the channels of recording their observations and opinions. The apathy that has existed, for the past score of years, in the matter of exchanging ideas, largely accounts, I am afraid, for the want of progress. Interest may be said to have been first prominently aroused in the subject of pests and blights by the late Mr. S. E. Peal's paper on "Mosquito" or, as he loved to call it, the "Tea Bug." Prior to the appearance of Mr. Peal's paper it had been vaguely designated "Blight," and was viewed as a mysterious visitation. Mr. Peal showed that it was caused by an insect. Immediately there arose the enquiry as to methods of extermination. From that date one discovery after another followed quickly until for twenty years or thereby the Journals of the *Agri.-Horticultural Society* and the public newspaper of Calcutta teemed with letters and detailed

Advantages of Exchange of Opinions.

Interest first Aroused by Mr. Peal.

reports on the pests and blights of the tea plant. Gradually, however, the subject seems to have lost interest, perhaps, through the discovery of new methods of cultivation and manufacture, that gave handsome returns in spite of the ravages of these enemies of the industry. Left thus to themselves they have multiplied and extended until attention has been forced once more to the question, which twenty years ago was discussed and pigeon-holed, by those most interested, *viz.*, the desirability of securing scientific assistance.*

ASSORTMENT of COLLECTIONS.

Scientific Officer to Investigate Blights.

319. In presenting this compilation of available information I may as well explain that I shall deal *first* with the Pests, and *next* with the Blights. Under Pests (Insects) I shall, as far as possible, follow the classification and the scientific determinations given in Mr. Cotes' *Insects and Mites which attack the Tea Plant in India.* It may, however, serve a useful purpose, if I attempt to indicate :—

Explanation of Letters Affixed to Names of Pests and Blights.

(*a*) The insects described in the Indian Museum Notes (including Mr. Cotes' special paper) as actually found on the tea plant in India. (The pests of this section will for the most part be found dealt with in Mr. Cotes' *Insects and Mites, etc.*)

(*b*) The insects found on the tea plant in Ceylon and which presumably may in the future be found in India.

(*c*) The insects discovered by me in addition to (*a*) and including also those which prior to the date of my explorations have been treated under the position (*b*) above.

320. These particulars will be brought out by the letters (*a*), (*b*) or (*c*) being placed alongside of the serial given to the species dealt with. My object in so doing is to exemplify once more the very remarkable fact that the pests and blights of the tea plant are rapidly becoming diffused over the world's areas of tea cultivation. A large percentage of these insects have never been seen by entomologists, except on the cultivated tea plant, though many are common enemies to both tea and coffee. It need hardly be repeated that these very striking circumstances point unmistakably to cultivation having produced the conditions necessary for the appearance and distribution of these pests, the more so since the wild tea plant has been found to bear but a small percentage of these pests. (*Conf. with paras, 11 also 44 to 49*).

Diffusion of Tea Pests.

Small Percentage on the Wild Tea Plant.

* See Proposed Scheme, Journ. Agri.-Horti. Soc. Ind., Vol. V. N. S. Proc., 24th Aug. 1876; 23rd Nov.; 21st Dec.; 19th April 1877; 23rd Aug.; Vol. VI. Proc., 18th Dec. 1879; Scheme Abandoned, 22nd July 1880.

The Coleoptera or Beetles.

LACHNOSTERNA IMPRESSA.

321. As a matter of convenience, I shall quote (at the end of the paragraph of references under each species) the registration numbers assigned to all pests collected by me and, when preserved in fluid, shall quote also the numbers engraved on the bottles or tubes in which they have been stored. These numbers, it will be understood, are given for Museum purposes only, and are of little interest to the general reader, except as indicating by their absence pest and blights of which specimens have not been procured and of which contributions would, therefore, be very acceptable.

COLEOPTERA.

LII.—The Beetles.

Larvæ of Beetles Known as Grubs.

322. In this Order of insects both the grub and the perfect beetle may injure crops. The maggots or grubs are sometimes devoid of legs, but more frequently have three pairs of jointed legs—one pair on each of the three segments of the body near the head, and a pair of sucker-feet near the anal extremity. The chrysalis looks like a deformed beetle, curled up and motionless. The perfect insect or beetle has an upper pair of hard wing-cases, called the *elytra*, and below these a pair of large membraneous wings that fold underneath the wing-cases.

There would seem to be five well-known species of beetles found on the tea, with perhaps three or four more that might be regarded as occasional enemies. The Cockchafer, or White Grub, in its larval stage eats the roots of the plant, and in its mature form would appear to devour the leaves as well. Then there are at least four species of leaf-feeders, that often do considerable damage to the crop, when prevalent. Lastly a wood-borer found in Ceylon, but not as yet in India. In Sibsagar district I came across a longicorn grub which is perhaps a by no means an uncommon tea-borer, though, so far as I can discover, it has not as yet been described.

COCKCHAFER.

I. (a) Lachnosterna impressa, *Burm.*

THE COCKCHAFER OR WHITE GRUB.

References.—*Tea Cyclopædia, 44; Notes on Tea in Darjeeling, 54; Tea Planter's Vade Mecum, p. 105; Bamber, Chem. and Agri. Tea, 242; Ind. Mus. Notes, Vol. I., 59; Vols. II., 149; III., 3, 122; Cotes, Ins. and Mites on Tea Plant in India, 5-7.*

(Reg. No. 21, tubes Nos. 264 and 233.)

The Cockchafer or White Grub.

LACHNOSTERNA IMPRESSA.

323. History.—The first mention of this beetle, as an enemy to the tea plant, so far as I have been able to discover, is contained in a letter by a Darjeeling Planter (1874) which will be found reprinted in the *Tea Cyclopædia*. The author of *Notes on Tea in Darjeeling* (1888), gives it the vernacular name of *Kumla*. Mr. Bamber says. "it occurs in all the tea districts," but does not tell us whether he had actually found it in Assam. Moreover, he makes the somewhat puzzling remark, "with the aid of lamps collecting the grubs at night when out to feed, would probably prove a satisfactory method for lessening their numbers." So far as I am aware the grubs of this beetle never under any circumstance come above ground and have no occasion to do so since their food consists of the young roots of the plant. Mr. Cotes remarks that it appeared in vast numbers in Darjeeling in 1891 (*vide* letter from Messrs. Davenport & Co., October 1891, *Ind. Mus. Notes, III.*, *3*). "Its prevalence in other years," Mr. Cotes adds, "is shown by the fact that in 1883 no less than 2,695,000 individuals were collected and destroyed in the public gardens, Darjeeling (*vide Ind. Mus. Notes, Vol. I.*, *59*). But Mr. Cotes makes no mention of its being found in Assam. It was collected by me in a few gardens of the Sibsagar District, more especially at Khumtai and Ligri Pukri. Mr. Crole (*Tea Text-Book, pp. 84 and 222*) incorrectly gives the scientific name of this beetle to the cricket.

2,695,000 Destroyed in 1883.

Discovery in Assam.

324. Depredations.—Like most of the predatory Melolonthin beetles this species lives in its larval stage on roots. The eggs are laid in the ground. From these the white grubs escape and very possibly attack the roots of weeds in the first instance. Ultimately they penetrate to the depth at which they are able to discover the roots of the tea plant and these they devour. Mr. Cotes suggests that the eggs are likely to be laid about the beginning of the rainy season, in Northern India. "How long is spent by the grubs in the ground before they become full grown we do not know, but the fact that the European species **Melolontha vulgaris**, *Fabr.*, spends more than three years in this stage, while the American species, **Macrodactylus subspinosus**, *Fabr.*, spends the greater part of one year, leads to the supposition that an equally long period may be required in India." (*Cotes.*) A tea-planter whose opinion will be found quoted below under the paragraph on

Grubs Live on the Roots.

Period of Larval Existence.

The Coleoptera or Beetles.

LACHNOSTERNA IMPRESSA.

" Remedy," thinks the Indian white grub may live in the ground for two or three years. At all events these grubs never come to the surface until after they have passed into the pupal stage, when in due course they emerge as the mature or copper-brown-coloured beetle.

Beetle Eating Tea Leaf.

At Khumtai on the 7th of April I witnessed this insect making its escape from the ground and found several of the mature beetles apparently eating the leaves of the plant. A large assortment of grubs in all stages of growth were sent me in December 1895 from another garden in the Sibsagar District. These were turned up while heavy hoeing, and the manager very properly thought that they had better be picked out. He accordingly sent me a selection and desired to be informed if they were insects reported hitherto to injure the tea. These larvæ I submitted to the Entomological Department of the Indian Museum, as there seemed to me to be at least two, if not three, species. The reply obtained was to the effect that " the larger grubs are the larvæ of a Melolonthin beetle probably belonging to the genus **Lepidiota**, and the smaller are apparently the immature forms of **Lachnosterna impressa**. The mud ball sent is the pupal cell of a **Copris** beetle." Mud balls or nodules, of the size of a large hen's egg, are frequently thrown up from the ground, during the hoeing of tea gardens, when the soil consists of a fairly heavy clayey loam. They are commonly seen on the faces of road cuttings and may easily be mistaken for the mud cells of queen white-ants. On being broken open they will be found to contain a grub of a brown colour that may sometimes be 2 to 3 inches long. The nodules are stratified and closely compacted, the inner layer being sometimes of a darker colour than the outer layers.

Other Grubs in Tea
Conf. with para. 328.

It would thus appear that in Assam there are possibly two species of beetle that attack the roots of the tea plant. Grubs of the nature mentioned should, therefore, be carefully picked out from the ground during hoeing.

Bushes Gradually Fade and Leaves Wither.

325. Appearance of the Bush.—When beetles of this family attack tea, the plant at first is seen to have lost its vigour. The buds often become *banjhi*, and as the ravages of the beetle advance the leaves droop, turn brown and finally the bush appears as if killed and it may actually be so. The appearance in fact is very similar to that when a wood-borer is at work (such as **Zeuzera coffeæ**), with this difference

The Cockchafer or White Grub.

that the whole bush appears to be suffering instead of one portion of it only, as is generally the case with borers. From what has already been said, of this beetle, it will be understood there may be very little evidence of its ravages for months, while the grubs are steadily sapping the life of the plant and not one plant, for, as a rule, the beetle, if present, invades a considerable area, so that a whole plot of tea may be seen to be injured and clumps of bushes killed. When this occurs, the bushes if dug up will very often be found to have the roots invaded by fungi, and the inference is sometimes drawn, though incorrectly, that the fungus is the cause of the destruction. When bushes are seen to die in the manner indicated, it would be a good plan to have a healthy bush, near to those killed, dug up and carefully examined. It may then be seen that the fungus is only saprophytic, that is to say, a species that attacks dead, not living, plants, and that the real cause of the death of the bushes is the white grubs that may then be found feeding on the living roots. **LACHNOSTERNA IMPRESSA.**

326. REMEDY.—So far no cure has been discovered, except to dig up the grubs and kill them. But to check the multiplication of the pest it is necessary to catch and destroy the beetles. For this purpose children, armed with insect-collecting nets, would be found most valuable, when incited through the offer of a reward for the number captured. The planter whose letter first drew attention to this pest, tells us that he offered a reward to his coolies, when hoeing the land, of one pice for every 30 grubs collected. In consequence the coolies dug more than their day's task, so that the collection of the grub practically cost nothing. He informs us, however, that "to clear 15 acres cost in pice R108—giving 2 lakhs of grubs which filled two hogsheads. The eggs from which these grubs sprang must have been laid some two or three years before, and most likely they have quietly been doing great mischief. I am in the habit of burying the jungle—not all over the land, but in small holes, here and there, where convenient. This I found a great trap, for the grubs left the tea trees to attack this rotting vegetation and so were easily collected." The author of *Notes on Tea in Darjeeling* gives somewhat similar information, though he adds certain additional facts. The grub, he says, is "generally found in very rich soil, or where manure has been put down, or much jungle has been buried. This is fairly destructive to young cultivation and seed-beds, and

Destruction of Mature Insect Desirable.

Collection of the Grubs.

Quantity Collected.

Burying Weeds.

Effects of Manure.

DIAPRO-MORPHA MELANOPUS.

eats off the roots of the young seedlings before they harden up, in some cases killing off nearly every plant in young cultivation. Only remedy digging up. Plants attacked by *Kumlas* generally die slowly, first getting yellow at top and gradually dying down. Never fill in a vacancy thus caused without digging the insect up." **Mr. Cotes** tells us that in Ceylon, on coffee estates "where Melolonthini larvæ at one time proved very troublesome, the only method of treatment that seemed to have been at all successful was digging out the grubs by hand." Speaking of the efforts made to extirpate an allied insect from the vines in Europe, bisulphide of carbon is said to have been used with success. **Miss E. A. Ormerod's** *Text-Book of Agricultural Entomology*, pp. 80, 89-93, will be found to give many useful hints regarding Cockchafers. **Mr. Saunders** (*Insects Injurious to Fruits*) gives some valuable particulars regarding a species of **Lachnosterna** said to be injurious to the cherry, plum, and other such trees. During the day the beetle remains in repose, but at night becomes active, and, if numerous, rapidly defoliates the trees. They are best collected by placing a sheet below the bushes, during day time and then shaking when the beetles fall into the cloth, and may be collected in large numbers. He then adds that where the beetles are found abundantly the grubs may be expected to remain for some years to come since the larvæ eat the roots during a protracted period of existence. The presence of this beetle even if it does not eat the tea leaves is a very dangerous prognostication of future injury, and it should, accordingly, be collected and destroyed as much as possible.

European and American Experience.

ORANGE BEETLE.

2. (a) Diapromorpha melanopus, *Lacord.*

THE ORANGE BEETLE, sometimes called PEAL'S BEETLE.

References.—*Journ. Agri.-Horti. Soc. Ind., Vol. II. n. s. Proc., Nov. 17, 1869, page ix; Vol. IV. (n. s.) Proc., 19th Sept. 1872, xl; Feb. 27th, 1873, p. vii; April 24th, 1873, p. xxii; Vol. V., Proc., 27th Aug. 1874, p. xlvi.; Vol. VI., Proc., 24th July 1879, p. xxii; (Samples from Moran), identified by F. Moore, Proc., 25th Sept. 1879, xxx; S. E. Peal, in Tea Cyclopædia, pp. 35-36; Notes on Tea in Darjeeling, 52; Bamber, Chem. and Agri. Tea, p. 242; Indian Mus. Notes, Vol. I., 106; II., 154; Cotes, Ins. and Mites on Tea Plant, p. 7; The Planter, June 20th, 1896; Crole, Text-Book, p. 222.*

(*Reg. No. 75, tube Nos. 62 and 272.*)

Early Records of this Pest.

327. HISTORY.—It would appear that **Mr. E. L. Edgar**, of Cossipore Tea Estate, Cachar, was the first to draw attention to this beetle. He

then wrote, that it had only appeared this year (1869) in any numbers. We next hear of it in 1872 from Moran in Sibsagar District, Assam. Both samples were sent through the Secretary, Agri.-Horticultural Society of India, to Mr. F. Moore, who identified them as being **Diapromorpha melanopus.** Mr. Peal sent samples of it to Mr. Wood-Mason along with such notes and coloured drawings that Mr. Wood-Mason undertook to write for the Agri.-Horticultural Society an account of the insect, which promises, apparently, he never fulfilled, as I have failed to trace a paper by him. Mr. Peal himself, however, contributed some interesting particulars in the form of an article on Tea Pests that will be found in the *Tea Cyclopædia*. The subsequent historic facts are soon told. It was reported from Darjeeling by many writers, and Mr. Cotes says, "The species is a common one in India." **DIAPROMORPHA MELANOPUS.**

328. DESCRIPTION.—A small orange-coloured beetle with the hard pitted wing-cases; head slightly darker coloured than the body; belly pale coloured. Size about ⅛th inch in length. **Small Orange-Coloured Beetle.**

329. DEPREDATIONS.—This very troublesome little beetle is one of those examples of an insect having left its own natural food and taken to the tea. Its life history does not appear to have been traced out, but Mr. Cotes says, "From what is known of other species of the same family, it may be expected that the eggs are laid upon the leaves, that the larvæ are active little creatures which feed upon the foliage, eventually transforming, in some sheltered corner, into stationary pupæ from which the beetles ultimately emerge. These points, however," he adds, "require corroboration." **Eggs Laid upon the Leaves.**

Mr. W. J. Fleet sent me, from Salonah, Nowgong, samples of this beetle on the 27th June 1897, which he collected on the 17th April, but had observed the beetle subsequently up to date of his letter. The winged insect was collected by me at Nigiriting on the 1st of May, and in the Sibsagar District some weeks earlier. I had a large supply sent me from Sonada, Darjeeling, in June 1897. The first two letters announcing the discovery of this pest make no mention of the date of appearance of the beetle, but these letters were published,—the one on the 17th November 1869, the other on the 19th September 1872. **Dates of Appearance.** **Periods of Appearance.**

It is curious that no writer makes mention definitely of the dates of appearance and disappearance of this pest. The above facts have been mentioned to show all that is known on these points. It may,

DIAPROMORPHA MELANOPUS.

therefore, be presumed that its period of depredation extends, say, from the beginning of April to about the end of August. One point there seems to be no doubt about. The insect does not lay its eggs on the tea, nor do the larvæ feed on tea. It is only the mature beetle so far, that has been seen on tea. I questioned the late Mr. S. E. Peal on this point carefully, and he assured me that it certainly did not breed on tea, but, in his opinion, lived its early life on *ulu* grass (**Imperata arundinacea**).

Mature Beetle, not Larvæ, Feed on Tea.

Appearance of Shoots Eaten.

Regarding the manner of its depredations there can be no doubt. Mr. Edgar, its original discoverer, says, "These insects scrape the green stem below the Pekoe or Pekoe-Souchong leaf, sometimes below the Souchong leaf if the flush is quick grown, and the stem soft. They scrape or eat a place on it from half an inch to one and a quarter inch in length and from just touching it to three-fourths through. According to the depth they go, so soon do the two or three leaves above tumble over and wither. Should they multiply, they will be very destructive to new flushes." The Assistant Manager of Moran Company, Assam, in his letter even goes more fully into the subject. He says, "So serious is it that I estimate a loss of at least a maund of tea from this flush alone, which I am now plucking, and the loss on the entire year must be very serious." "The insect eats or gnaws only a small portion of the stem of the young shoot, which, whenever the sun touches it, withers, droops, and in about a day falls off and then the shoot looks just as if it had been plucked; so that to discover the entire depredations of this little pest, the bushes have to be examined once or twice every day." Mr. S. E. Peal's original account of this pest is also worthy of being quoted, since it throws some additional light on the methods of procedure adopted by this insect. "Naturally," he says, "it is a grass-eater, and may be found in considerable numbers where larger grasses abound in the open. It has a habit of alighting on the tips and flies rather slowly, resting under the curved-over tips of the *ulu* grass. These insects are at times found in threes or fours, and rest there in the little shade afforded. In attacking tea, they generally eat away portions of the green stem of the shoot that is just fit to pluck; the shoot falls over, withers, dies, and turns black and dry. If this beetle is at all common, considerable damage is done, and a garden or patch of tea presents a brown, withered appearance. As the portion eaten out

Loss Sustained.

Presence of *Ulu* Grass Dangerous.

The Orange Beetle.

of each stem is not large, a single beetle may ruin half a dozen shoots as one morning's work."

DIAPHO-MORPHA MELANOPUS.

The author of *Notes on Tea in Darjeeling* says, "This is a small reddish yellow insect, which always runs up if cow-dung has been put down, and sometimes on new extensions, probably from the same cause. This beetle seems to attack heavy pruning or young tea more than pieces. It bites the shoot low down, and the shoot then withers and rots away. If there is sun-grass near the tea, the beetle goes to the grass, instead of the tea."

Attack Young Tea.

Mr. Bamber did not evidently give much attention to this pest as he devotes only some two lines to it and says, "at present the damage done has been small." Mr. Cotes (*Insects and Mites, etc.*) gives no particulars as to its depredations, but refers to the *Indian Museum Notes, Vol. I., p. 106,* where it is stated that specimens had been received from Mr. S. E. Peal in 1885. A Darjeeling correspondent in *The Planter* says, "Often when reading articles on tea blights I have been surprised never to have seen the 'Orange beetle' mentioned." "I have often seen a dozen or more of these beetles on one bush and every bud lying over dry and making the bush look almost as though withering up at first sight. Another peculiarity about them is, that they only seem to go for the Assam *jats,* and are scarcely ever seen on a China bush, evidently preferring the more succulent shoot of the Assam bush to the less juicy one of the China."

Prefers Assam *Jats.* *Conf. with paras. 49, 71-2, 198.*

The fact of this insect showing a decided preference for the Assam tea is a point of considerable interest. This I had recorded in my diary and found, when in Assam, that Mr. Peal and others had made the same observation.

330. REMEDY.—In consequence of our ignorance of the early history of this insect, only the one cure is open for consideration, namely, to collect and destroy the beetle. This Mr. F. Moore recommended over 20 years ago, and nothing further has been brought to light. Mr. Peal was of opinion that far from *ulu* grass being a protection (as suggested by the author of *Notes on Tea in Darjeeling*) it is the chief cause of the mischief. While walking through one of the Moran Company's gardens Mr. Peal stripped the long blades of *ulu* grass through his hand and demonstrated to me thereby the day habitat of the insect. But while Mr. Peal speaks of the insect accomplishing its ravages in the morning I found the insect in the Golaghat

Early History Not Known.

Hours of Eating.

The Coleoptera or Beetles.

DIAPROMORPHA MELANOPUS.

Sub-Division most active late in the afternoon. It is thus probable that it feeds both in the morning and in the afternoon.

A planter whose letter originally appeared in the *Tea Gazette*, says, "I have had thousands of bushes damaged by this insect, and find it pays 'hand over fist' to give coolies so much for catching the little pests, say a pice for fifty. By so doing I have succeeded in destroying as many as 20,000 in the day." Mr. Peal says, "eight or ten well-made butterfly nets, depth, say, 18 inches, and diameter of mouth 1 foot, ring or hook of stout brass wire, bent, soldered and inserted in 4 feet high bamboo handles. These in the hands of as many smart boys will bring down the numbers very rapidly. If at all plentiful, a boy can easily 'bag' 300 beetles per hour, and where not much of a pest, I have taken several times myself at the rate of 250 per hour. A few days of this and the nuisance will abate very perceptibly."

20,000 Caught Daily.

300 Captured per Hour.

LADYBIRDS.
Conf. with para. 614.

331. LADYBIRDS BEETLE MISTAKEN FOR THE ORANGE BEETLE.—I desire in passing to warn those, unfamiliar with the appearance of the Orange Beetle, not to be too hasty in coming to the conclusion that any small orange-coloured or red beetle, found on tea, is the pest here dealt with, or "at all events has no business" on the tea and had, therefore, better be removed. While visiting a garden in the Sibsagar District, the manager informed me that some ladybirds that I had caught and was examining were Peal's Beetle. I assured him he was mistaken and that the ladybird was one of the planter's best friends. It was no good my protesting that he was mistaken for "some years ago they had caught that very insect by the thousands daily." Of course this was a case of mistaken identity. The insect to which he alluded, as having been collected, I found subsequently was the orange beetle right enough. The ladybird beetle is almost circular in outline and of a bright red colour with a few spots on its wing-cases. The orange beetle is a narrow elongated insect with a somewhat large and curiously truncated head, as if cut off abruptly. The wing-cases are of one uniform orange yellow colour throughout and seem as if some one had dabbed them all over with the point of a needle—the surface of the wing-case being pitted. The wing-cases of the ladybird are perfectly smooth and polished.

Planter's Best Friend.

The larvæ and even the mature insect of the ladybird beetle are carnivorous and feed for the most part on the black aphis (Ceylonia

theæcola), and I believe also on the larvæ of the mosquito and green-fly. I have watched them repeatedly devouring the black aphis, and been surprised that colonies of these curious aphides were not alarmed by the appearance among them of so formidable an enemy. They seem undisturbed and await their turn of destruction perfectly unconcerned. **ASTYCUS CHRYSOCHLORUS.** **Carnivorous.**

The ladybird does not injure the tea in any way and should most certainly be encouraged, on no account destroyed, through the mistaken notion of its being the orange beetle.

3. (a) Astycus chrysochlorus, *Wied.*

THE GREEN BEETLE. **GREEN BEETLE.**

References.—*Indian Museum Notes, Vol. III., 99, 126 : Cotes, Ins. and Mites, etc., 8.*

332. HISTORY.—I have given this insect the name of Green Beetle as a simple and characteristic description. Mr. Cotes tells us that it "was sent to the Indian Museum in April 1892 from a tea garden in Cachar, where it was supposed to have been the cause of some injury to the bushes. It was said to strip the young leaves off the tea shoots."

333. REMEDY.—Nothing further can be said than has already been mentioned in connection with the orange beetle. The insect should be collected and destroyed whenever seen. As with all others so with this species, it may be said, that the sooner the pest is attacked the better. It is, however, unfortunate that we have to confess ignorance of the actual life history of this beetle.

4. (c) Astycus lateralis, *Fabr.*

(*Reg. No. 102, tube No. 131.*)

334. HISTORY.—Messrs. Balmer Lawrie & Co., on the 3rd of June 1897, were good enough to forward to me a few beetles that had been sent to them from the manager of the Hukanpukri Division of the Jokai Company's estates. Mr. E. Ramsden in forwarding the specimens reported that they had been found on one-year-old plants. They had come during the night in thousands and simply stripped the bushes. Fortunately they were easy to catch. My reply identified the insect as a species of **Astycus**. Subsequently, however, on re-examining the specimens, I came to the conclusion that it might possibly be a species already identified by entomologists. I accordingly sent the samples to Dr. Anderson, of the Indian Museum, and he was good enough to inform me that the name of the insect was as above

ASTYCUS LATERALIS.

(A. lateralis). It is a much smaller beetle than **A. chrysochlorus,** is of a dark brownish black ground colour, with a distinctly green metallic tinge. The chief difference to the non-professional eye may be said to be that **A. chrysochlorus** is about ¾ of an inch in length and is of a bright pale green colour, while **A. lateralis** is about half an inch long and of a dull metallic green.

335. Remedy.—There is nothing further to remark on this point than has already been said regarding **A. chrysochlorus.**

5. (c) Astycus ? *sp. nov.*

(Reg. No. 101, tube No. 72.)

336. History.—A black beetle with a metallic green tint, is not uncommon in Assam as a tea pest. At first I took this to be **A. chrysochlorus,** but, on comparing at the Museum my specimens with the beetle from Cachar, I agreed with Mr. Barlow that it must be regarded as a distinct and possibly an undescribed species. In point of size it is intermediate between **A. lateralis** and **A. chrysochlorus,** but in colour is more like the former than the latter.

I was shown specimens at Amguri, by Mr. Buckingham, which he had collected some time prior to the date of my visit. The insect had not appeared very severe but was known all over the Sibsagar District. It came one year, gave considerable cause for anxiety, and then disappeared for a number of years, perhaps to re-appear when least expected.

337. Depredations.—At Dirpai, North Lakhimpur, on the 8th July I found a colony of this beetle doing much damage to some 10 to 12 bushes all near each other in one portion of the garden. The beetle commences on the margin of the leaf and eats downwards towards the midrib. When about half way down it commences on a new place, so that great ugly holes are cut out of the leaf.

Remedy.—Same as for the other beetles dealt with under this genus.

6. (b) Xyleborus fornicatus, *Eichhoff.*

WOOD-BORING BEETLE.

Wood-Boring Beetle.

Reference.—*Indian Museum Notes, Vol. IV., p. 57, Plate V., Fig. 2.*

338. History.—This curious little beetle has been found in Ceylon to riddle the tea stems. Specimens were sent to the Indian Museum on the 20th January 1897 by Mr. E. E. Green, and were forwarded

to Mr. W. F. H. Blandford, who identified the pest as the beetle above named. **XYLEBORUS FORNICATUS.**

339. Depredations.—Mr. G. Alston, Superintendent of Craighead, Nawalapituja, who first drew Mr. Green's attention to this new tea pest, wrote that it appears mostly in patches. "Most of the trees show no outward sign of the pest, except when almost every branch is attacked, when they turn rather yellow and stop flushing. Young trees about two years old, before they are topped, often snap off at the spot where the borers have made holes for their entrance or exit. Strong vigorous trees in good soil seem to be very little affected by it, and threw out good red wood even from badly bored stems. On the other hand, poor plants on ridges or poor soil seem to naturally feel the effect of it quickly, though in no case have I seen a tree *killed* by it. Isolated branches die off, but new branches come out in their place. As a rule, you can only tell an attacked tree (except in the case of young plants, when the stems snap off) on pruning it, when the holes in the wood are very apparent. It (the beetle) does not attack the cut surface after pruning, but makes its entrance through the back. In the case of young red wood it very generally goes straight down the pith; in older branches I have often seen the wood riddled as if a charge of snipe-spot had been fired into it, with only one or two minute holes in the bark for exit or entrance. And yet in the case of vigorous trees they seem to thrive notwithstanding. Since 1893 the pest has spread very much, and become more general, though I cannot say that I see much difference in the fields that were attacked then." The plate quoted above is an excellent one, but if the reader possess a copy of Miss Ormerod's useful little *Text-Book of Agricultural Entomology* he will find (*p. 100*) an illustration of the very closely allied species **X. despar** which shows the ravages of the European species on the plum.

Branches Die off.

Entrance Made through the Bark.

Vigorous Trees do not seem to Suffer.

340. Remedy.—It would be dangerous to suppose that because strong, healthy, well-nourished bushes seem little affected by this pest that there is no occasion to take steps to secure its eradication. Should it appear in the Indian tea areas, every effort should be at once made to stamp it out. Improve the vigour of the plant by manuring, deep drainage and other means. Lop off and burn all affected parts. If found in a small compact area I personally should, however, prefer to fire the plot. In my experience this is by far the

Should be Instantly Eradicated.

CURCULIO TANYMECUS.

Fire might be resorted to.

most effectual remedy with all diseases that occur over fixed and limited areas, more especially if the disease is recognised and the firing can be accomplished early in Spring. All over the plot dry straw should be placed within and through the bushes so as to secure rapid combustion. The embers should be at once cleared away from the bark of the main stem. After the fire has burned out, the bushes should then be pruned and all charred portions removed. The Spring shoots may be delayed a few weeks, but in exceptional cases only will the bushes be killed, unless the firing be done late in the season.

LIII.—Other Beetles Reported as Attacking the Tea.

7. Curculio tanymecus.

341. In the Journal Agri.-Horticultural Society of India, *Vol. VI. n. s. Proc., 24th July 1879*, mention is made of a beetle sent to the Society by **Messrs. Williamson, Magor & Co.,** "as doing much mischief to the tea bushes in the Munguldye Company's plantations." The specimens were forwarded to **Mr. A. Grote** and ultimately submitted to **Mr. F. Moore**. The reply appears in the Proc. of the 18th December 1879. "The green beetle sent to you by the Munguldye Company is a **Curculio** allied, as **Moore** thinks, to **C. tanymecus,** but these beetles ordinarily bore into the stem and branches of plants and do not meddle with their leaves.". I am unable to trace the name **C. tanymecus.** There is a genus of beetles known as **Tanymecus,** but **Gemninger** and **Harold** make no mention under **Curculio** of a species **C. tanymecus.**

342. It is somewhat significant that the pest alluded to, in above correspondence, should apparently have disappeared while two species of **Astycus** (that are by no means remote from **Curculio**) should have taken its place as leaf-defoliators in Assam.

8. *Two other species of beetle have been sent to me by* **Mr. Fleet,** as injurious to tea, *viz.*, **Crioceris impressa** and **Oides bipunctata.** I have obtained no particulars regarding these beetles, and mention them purely in order to suggest further enquiry.

9. Grubs of **Lepidiota** and of **Copris** have been mentioned above (*p. 184*) as having been sent from a tea garden, but in addition I have before me now a third grub, *viz.*, that of a Longicorn beetle (*Reg. No. 103*) which has been reported as doing much injury to the tea. The Longicorn (Cerambycid) beetles are mostly dangerous wood-borers.

CRICULA TRIFENESTRATA.

CHAPTER XI.

LEPIDOPTERA.

LIV.—The Moths and Butterflies.

MOTHS and BUTTERFLIES.

343. It is perhaps hardly necessary to explain that the insects of this Order pass through three complete phases.—(*a*) In the imago or perfect phase they have, as a rule, two pairs of wings, and these are coated with minute and variously shaped scales, hence the name **Lepidoptera**. (*b*) The caterpillars that emerge from the eggs constitute the second phase, and it is these that are destructive to crops, the perfect insect being, as a rule, quite harmless. The caterpillar of a moth or butterfly is at once distinguished from the grub of a beetle by the possession of one to four pairs of sucker feet (or prolegs) placed near the middle of the body. (*c*) Lastly, when full fed, the caterpillars molt and form the chrysalis or resting phase.

Caterpillars of Moths.

344. Butterflies may generally be recognised from moths by the antennæ resembling little drum-sticks. They may be said to be day-loving insects, whereas the majority of the moths come out during twilight or at night. So far only one butterfly (**Pareba vesta,** *Fabr.**) has been found feeding in the caterpillar stage on the tea, but unfortunately the series of moth caterpillars is both extensive and in some cases serious.

Butterflies.

345. The most successful method of dealing with caterpillars, hitherto practised, has been to hand-pick them. They are easily seen, and their depredations for the most part at once visible. But it would be a more successful plan still to collect the harmless-looking chrysalides or even to train a gang of children to capture the winged insects. In the winged state they are harmless, yet it must be recollected that they are then flying about to deposit the eggs that give origin to new generations of caterpillars.

Collection of Insects.

Eggs.

Family SATURNIIDÆ.

10. (c) Cricula trifenestrata, *Helfer.*

CRICULA SILK-WORM.

CRICULA SILK-WORM.

References.—*Hampson, Fauna British India (Moths), Vol. I., 28; Dict. Econ. Prod., Vol. VI., (Pt. III.), 88-93.*

(Reg. No. 51.)

* It is fairly common in Assam tea gardens (tube 245), only occasional in Darjeeling (No. 143).

Lepidoptera (Bombycidæ).

ANDRACA BIPUNCTATA.

346. HISTORY.—This silk-moth caterpillar has never before been recorded as a tea pest. It was sent to me by Mr. J. Lees, of Borsillah, Jorhat Sub-Division, Assam, as doing a certain amount of damage to tea. The cocoons sent were attached in considerable numbers to the tea shoots. Mr. Green writes me that this insect, though common on several wild trees in Ceylon, has never been seen by him to attack tea.

Family BOMBYCIDÆ.

II. (a) Andraca bipunctata, *Wlk.*

THE BROWN or BUNCH CATERPILLAR. *Conf. with paras. 426, 478.*

THE BROWN OR "BUNCH CATERPILLAR:" A pest often designated simply "CATERPILLAR."

References.—*Hampson, Fauna, Br. Ind.* (*Moths*), *Vol. I., 40; Jour. Agri.-Horti. Soc., Ind., IV. n. s. Proc., 21st Nov. 1872; V., 23rd August 1877, xxxviii; Peal, in Tea Cyclopædia, 35; Tea Planter's Vade Mecum, 105; Baildon, Tea in Assam, 46; Ind. Mus. Notes, Vol. III. (pt. 1), p. (?)2-3, also (pt. 5), 58-59; IV., 41? Cotes, Insects and Mites, etc., 22-23.*

(Reg. No. 5, tubes Nos. 149, 166, 192, 202, 315.)

347. HISTORY.—The earlier writers on tea pests speak of this insect as "Caterpillar." Mr. J. S. Michael, a Cachar planter, appears to have been the first to draw attention to it, *viz.*, in 1872. It is next mentioned by Messrs. J. Mackillican & Co., in 1877. Mr. Peal may be said to have followed very closely on the above, for he furnished an account of "Caterpillar" in the *Tea Cyclopædia.* That this caterpillar had appeared in Assam simultaneously with Cachar may, therefore, be accepted, but curiously enough Mr. Bamber makes no mention of it. It is at once the most abundant and most evident of all moths that attack the tea plant in Assam. Mr. Cotes appears to have been made acquainted with it as a tea pest in 1893, through samples furnished by Messrs. Jardine, Skinner & Co. from their Cachar Gardens and from the Assistant Commissioner of Jorhat in Assam. But he makes no mention of this pest being found in Darjeeling, nor in the Duars, and curiously enough, while I found in every garden on the south bank of Assam, I was assured it did not occur on the north. I certainly did not come across it during my explorations on the north side of the Brahmaputra. It is said to do much injury to wild tea in the Lushai country.

Distribution.

Live in Compact Masses.

348. DESCRIPTION.—Most planters call this the "bunch caterpillar" from the circumstance that during the day the larvæ live in a compact mass. When full grown, they become two and half inches long and a quarter to three-eighths thick. They are smooth and

hairless, of a grey colour with lateral brown blotches on each segment, and three faint whitish lines drawn parallel to each other lengthwise and across the other markings. Over the prolegs there are small red patches or streaks.

BROWN OF BUNCH CATERPILLAR.

349. At Moran, on the 8th April I recorded in my diary the following observations regarding this caterpillar. They attach themselves to the tea in vast colonies. They hold on by the anal legs, and, when disturbed, simultaneously extend their bodies in a threatening manner. They are always seen during day in these colonies or bunches, and are thus easily collected. At night they disperse all over the bush or bushes and leave whole plots of the garden defoliated by the morning. From Mr. J. A. Thomson, of Ligri Pukri, Nazira, I obtained a most excellent series of samples, accompanied with the following note: —"I have now satisfied myself regarding every detail in the life history of this insect. In illustration I send a series of eggs, larvæ in all stages, cocoons and moths. It lays its eggs on the under side of the leaves. These are arranged very methodically, and each female deposits from 50 to 200 eggs. Each such deposit becomes afterwards a colony of caterpillars that remain together. In about a week the eggs hatch and the caterpillars take nearly a month to reach maturity. The insect breeds all the year round, but it is most prevalent in May, June and July. Mr. Cotes is quite wrong, in his *Insects and Mites of the Tea Plant*, both in the description and figure, where he says that 'The cocoon is a loose silken structure attached to the twigs of the tea plant.' The cocoons are formed, one might say, below ground or rather on upturned corners of clods and near the base of the stem. I am collecting just now maunds daily both of the caterpillars and cocoons." This is a curiously exceptional feature in the habits of a Bombycid, but certainly the cocoons in my possession give only occasionally indications of their having been attached to small twigs. They are often aggregated together into threes and fours, and the united structure shows a flat face such as might be formed by attachment to the main stem or to upturned clods of earth.

Defensive Movement.

Feed during Night.

Eggs Laid on the Leaves.

Breeds all the Year.

Cocoons on the Ground.

350. Depredations.—The caterpillars of this moth feed at night and often defoliate the bushes over large portions of a garden before the morning. Mr. Peal says that half a maund of caterpillars can be collected by five or six children daily. Mr. Baildon remarks that "they strip bushes of every vestige of green, leaving nothing but

Caterpillars Collected Daily.

ANDRACA BIPUNCTATA.

hard stalks. From six to eight weeks are generally required for the bush to recover itself, for the most minute buds are taken off as well as the large leaves." Mr. Cotes mentions a case in Cachar where in "six months, ending May 1893, it was found worth while to spend some fifteen hundred rupees in employing coolies to pick the insects off the bushes. In this case no less than sixty-nine and a half maunds of caterpillar were said to have been destroyed—a goodly quantity when it is remembered how voracious is the appetite of each individual insect." At a garden in Sibsagar visited by me on the 12th April, the superintendent showed me the day's collection of caterpillars, a large tub full to the top. He remarked that "they were not bad just now, but a few years ago 8 to 10 maunds of them were collected daily."

69½ maunds Collected. *Conf. with para. 444.*

8 to 10 maunds of Caterpillars Daily.

It would be interesting to know how many, averaged-sized caterpillars of this species, go to the pound. It might then be possible to come at some approximate idea of the total number of individuals killed in Assam per annum. I should fancy that 50 maunds a year would not be an excessive annual average estimate for the province. No garden on the south bank could be said to be free from this pest.

Collection of Caterpillars, Cocoons and Moths.

351. Remedy.—There is but one cure, *viz.*, hand-collecting, in other words to pick the worms; to see that the cocoons met with during hoeing are carefully gathered and destroyed; and similarly to send out children to capture the perfect insects, thus checking the deposit of eggs. Fortunately this pest is not a difficult one to deal with, since during the day (as already mentioned) the worms crowd together in vast numbers, and a handful may, therefore, be lifted at once.

Family SPHINGIDÆ.

12. (c) Chærocampa alecto, *Linn.*

SPHINX MOTH.

SPHINX MOTH.

References.—*Hampson, Fauna British India (Moths), Vol. I., 85.* *(Reg. No. 38, tubes Nos. 293 and 300.)*

352. History.—The caterpillar of this moth was collected by me from tea bushes at Ligri Pukri, Nazira, and a good supply of live worms and chrysalides were sent me, in April 1895, by Mr. J. Begg, of Moriani. I found the caterpillar occasional all over the Assam tea gardens, but nowhere in such numbers to be regarded more than a curiosity. The pale-green, smooth, hairless caterpillar with an erect tail-process and having circular spots on each somite, the most

Green Caterpillars.

anterior one being large elevated and of a brown colour, is a striking creature that can hardly be overlooked.

LOBSTER CATERPILLAR.

Mr. Green, to whom I sent a specimen, informs me that this moth is not known to feed on tea in Ceylon.

Family NOTODONTIDÆ.

13. (a) Stauropus alternus, *Wlk.*

THE LOBSTER CATERPILLAR.

LOBSTER CATERPILLAR.

References.—*Hampson, Fauna British India (Moths), Vol. I., 149-50; Green, Insect Pests of the Tea Plant, pp. 25-29, Fig. 6; Bamber, Chem. and Agri. of Tea, 244; Ind. Mus. Notes, Vol. II., p. 153; Cotes, Insects and Mites, etc., pp. 10-11.*

(*Reg. No. 63.*)

353. HISTORY.—Mr. Bamber remarks of this moth that it is "said to attack the foliage of tea and cocoa in Ceylon, also seen in Darjeeling." He then adds, "the damage done in India is very limited." Mr. Cotes, upon the above authority, gives this as a tea pest in Darjeeling. Sir George Hampson does not mention the species as found at Darjeeling.

354. DEPREDATIONS.—It was collected by me at Moaband on the 28th April, and the specimens, when shown to one or two planters, were identified as the caterpillar that some short time previously had done considerable damage to several gardens. At Amguri Mr. Buckingham had informed me that he had known the caterpillar do very considerable mischief. This species may, therefore, be accepted as one of those curious cases of spasmodic development that are of so frequent occurrence. An insect suddenly assumes alarming proportions and as mysteriously disappears again, for a number of years. The caterpillars of this moth apparently feed in the evening. They eat the leaves from the apex right down to the petiole, and deposit large curiously formed excreta on the leaves by which their presence may readily be detected.

Sudden Development.

355. DESCRIPTION.—I was unfortunately unable to rear the worms collected and failed to find any cocoons, but I had Mr. Cotes' description and figure with me at the time, and compared the live caterpillars very carefully with the drawing on page 11. The insect found by me differed in some respects, so that I am disposed to think it may prove a distinct species. During day it sits in the curled-up attitude figured by Green, and, as he very properly remarks, may then be readily mistaken for a brown withered leaf. It remains perfectly still. The

Lepidoptera (Notodontidæ).

STAUROPUS ALTERNUS.

first pair of legs are much reduced and look like antennæ. The next two pairs are greatly, one might say abnormally, elongated, and in the day attitude remain folded down at the knees so that they marvellously resemble the veins of a leaf, while the hindmost pair of prolegs appear never to be used for progression, but assume a fixed erect attitude, in imitation of the petiole of the supposed withered and shrivelled leaf.

Leaf Mimicry.

In general colour the creature may be said to have the chocolate brown tint of a fallen leaf, except for the rich, deep chestnut velvety patches and bands of white, that this remarkable creature possesses. But these are not unlike openings or perforations in the mimiced leaf. I came across nothing in Assam that struck me as being half so eccentrically formed, and can well understand that its configuration and attitude might easily be supposed to protect it from caterpillar-feeding birds.

Coloration and Attitude.

Special Peculiarities of the Assam Caterpillar.

356. It differed, however, from the description of the caterpillar of **Stauropus alternus,** sufficiently to make me suspect it may be a distinct species. The fifth, sixth and seventh somites had creamy white oblique bands, near their pointed and paired extremities, the eighth had no markings, while the ninth had a claret-coloured longitudinal band fringed on both sides with white. The tenth somite, instead of being pointed below, as in the figure given by Moore and by Cotes, was flattened and deflexed over the fourth pair of prolegs. The terminal somite was, as Sir George Hampson says, swollen and carried over the back (instead of being turret-shaped), but the anal prolegs were certainly not absent as Sir George says they are. These points of difference, therefore, seem to justify the inference that the Assam Lobster Caterpillar may not be **Stauropus alternus,** but, if so, it is certainly a closely allied species.

Family SYNTOMIDÆ.

14. (c) Syntomis cyssea, *Cram.*

References.—*Hampson, Fauna British India* (*Moths*), *Vol. I., 213.* (*Reg. No. 104.*)

357. The caterpillars of this very plentiful Assam moth were found eating the tea leaves by Mr. J. A. Thomson, of Ligri Pukri, who was good enough to rear these and furnish me with the moth. So far this can hardly be called a tea pest, though it seems as well to record the fact that it had been found feeding on the tea plant.

BAG-WORMS.

Family ZYGÆNIDÆ.

15. (c) Pintia ferrea, *Wlk.*

References.—*Hampson, Fauna British India (Moths), Vol. I., 258.*
(Reg. No. 105.)

358. I am also indebted to **Mr. J. A. Thomson** for having furnished me with the moth of this species reared on tea. It is but rarely met with and can hardly be designated a pest. **Mr. E. G. Green** informs me that the nearly allied moth, **Heterusia cingala,** *Moore,* has appeared in Ceylon as a tea pest. "The caterpillars, he writes, have occasionally been very prominent, defoliating the tea over large acreages at a time. Fortunately, the caterpillar is very subject to the attacks of a Tachinid fly which usually prevents the appearance of a second large brood. From over a hundred living caterpillars sent to me from one infested estate, I only succeeded in breeding out three moths, all the others were killed with the fly which emerged in hundreds in my breeding cages. *Some of the cocoons contained as many as twelve* pupæ of the fly apiece."

A Useful Parasite.

LV.—Bag-worms, Faggot-worms, etc.

Family PSYCHIDÆ.

359. This Family of moths is, perhaps, the most dangerous of all Lepidopterous pests. There are many species found on tea in Assam and Kangra, a good few of which I have been able to identify, with **Mr. Green's** generous assistance, and the facilities afforded me at the Indian Museum. Others I have left for the present under their possible generic designations. During my rapid tour through Assam, I was in many cases only able to collect caterpillars, and consequently have not got the complete series of worms, chrysalides and moths to enable me to name them. The notes which I wrote up in my diary regarding these tea pests may, I trust, however, enable the practical planter to recognize the forms to which I allude, and the filling in of their scientific names may, therefore, be left over for some future occasion.

BAG-WORMS.

Identification.

The bag-worms differ from all the other moths already described, in that the caterpillar forms around itself a small house by fastening together fragments of leaves, twigs or other portions of the tea plant. It thus snail-like carries its house on its back and pops inside on the slightest alarm. When it has reached its full growth, the bag or bundle of faggots is tied up to a branch. The worm then inverts

Peculiarities.

CLANIA CRAMERI.

itself so as to bring its head where its tail was formerly, and there remains till the time comes for it to escape as a winged moth. But, as a rule, only the males become winged, the females continue within their little houses. The males come and mate with them and the eggs are laid within the house, thereafter the female dies. As a rule, there are only a few males and many females, so that insects of this family are rarely seen on the wing. Perhaps of a hundred cocoons that may be preserved in a breeding cage, so as to procure the males, only two or three will be obtained.

Apterous Females.

360. It is, therefore, most important not to regard the dead-looking old bags or faggot-houses as past any danger. They may be literally packed full of eggs from which a large progeny of young caterpillars would most certainly come forth. All should be collected and destroyed. **Mr. Green**, in a letter to hand, remarks what it will be seen, from the description below, to be my experience also, that the smaller and more obscure members of this family are the most destructive as tea pests.

The Eggs.

16. (a) Clania (Eumeta) crameri, *Westw.*

THE FAGGOT-WORM.

FAGGOT-WORM.

References.—*Hampson, Fauna British India (Moths), Vol. I., 291; Jour. Agri.-Horti. Soc. Ind., IV. n. s. Proc., 29th May 1873, xxv; June 26th, xxxi; 21st August, xxxiv; Vol. V., Proc., 30th July 1874, xxxvi; Peal, in Tea Cyclopædia, 36; Green, Insect Pests of Tea, 3-8, Fig. 5; Bamber, Chem. and Agri. Tea, 243; Indian Museum Notes, Vol. I., 204; II., 157; III., 133; IV., 17-18, 41; Cotes, Ins. and Mites, etc., 14.*

(*Reg. No. 24, tube Nos. 86, 261.*)

361. HISTORY.—It is a little difficult to be certain that this insect is actually indicated by the very obscure descriptions handed down to us by some of the earlier writers. Moreover, the next species **(C. variegata)** has been sometimes known to assume the same condition of a faggot-house. It seems safe, to believe, however, that **Mr. G. F. Pinney**, of Rungajam, in Assam, was the first to draw attention to this as a tea pest. His letter which appeared in 1873, in the *Journal of the Agri.-Horticultural Society of India*, induced **Dr. R. A. Barker** to inform us that he had found it in the Darjeeling Terai. Perhaps the next notice of historic value is a letter from Tezpur, 1874, in which this insect is spoken of as having proved very destructive. **Mr. Peal**, speaking of the PSYCHIDÆ says, one species makes its case of twigs. **Mr. Green** tells us that before the introduction of tea in

Ceylon, this psychid was common on coffee, so that it is an old offender. Mr. Cotes remarks that specimens of it had been sent to the Museum "from tea gardens alike in Sikkim and Assam." An old and experienced Cachar planter, to whom I showed my collections of tea pests the other day, informed me, however, that this species, so far as he was aware, does not occur in Cachar, but that No. 18 (*c*) below was there extremely common. FAGGOT-WORM.

362. DESCRIPTION.—It seems hardly necessary to say more than that it is the common faggot-worm of Assam. The caterpillar nips off short lengths of young twigs (not leaf stalks), and fastens these together parallel to each other, and each extending the whole length of the house. In Assam these faggot-cases generally average from 1½ to 3 inches in length, and ½ to 1 inch in diameter. Mr. Green, to whom I sent samples, informs me they are larger than he had ever before seen **C. crameri** to assume, and suggests that they may possibly be **C. variegata.** They certainly are much larger and coarser than the faggot-cases figured either by Green or in the Museum Notes, *Vol. IV., pp. 17-18, pt. III., Fig. 2.* Mr. Moore's description of the last mentioned plate, *viz.*, "Larval case covered with slender twigs of irregular length, which are disposed longitudinally side by side *in a somewhat spiral form*," is scarcely applicable. I have rendered the concluding words in italics, because in the insect found in Assam (to which I here allude) the twigs are approximately of one length and are never in any respect arranged in a spiral form. It seems to me, therefore, that it is more than likely the common Assam faggot-worm may prove a distinct species. In part support of this suggestion I would add that, on the worm retiring within, it closes the mouth of the faggot-case by an operculum-like lid which is hinged to the top. The worm itself has no protecting mantle, as seen when extended out of the faggot-house in walking, or while feeding. The final determination of the species can only be accomplished by some person placing a large number of faggot-cases in a breeding cage, and thus securing a few of the perfect male moths. I was unable to do this during my rapid tour, and have retained the present account under **Clania crameri** as a matter of convenience, rather than accurate determination. It would be most instructive to obtain particulars as to the period of larval life and the number of generations that are produced a year.

May Prove Distinct.

Lid to Close its Faggot House.

Information Required.

Lepidoptera (Psychidæ).

CLANIA CRAMERI.

363. Depredations.—When present in very large numbers, this insect may do harm, but I cannot say that I came across a locality in Assam where the bushes were badly injured by it. Of course it does some harm by nipping off the twigs to make its faggot house, and doubtless by eating the leaves also. Mr. Green says, " The larva has a habit of billeting itself upon some young plant, and not only devours the leaves, but cuts off the woody shoots for building purposes." But I should not be surprised were it proved that the large Assam species feeds mainly on the bark, and, if so, it may be more destructive than might at first appear. It is by no means so dangerous, however, as the smaller species of Psychids to be described hereafter.

Collection of Faggot-cases.

364. Remedy.—The only cure is to collect the faggot-cases and burn them. It should be recollected that the female is an apterous creature that never leaves her house, so that old and dead-looking cases, as well as those seen moving about, should be collected, since the former may contain the eggs. Mr. Cotes very properly remarks that " the most remarkable feature about the caterpillars is their extraordinary vitality. Indeed, they will withstand an amount of rough handling which would be fatal to the larvæ of almost any other group of Lepidoptera. The point is an important one in considering how best to dispose of what are brought in by coolies."

BAG-WORM.

17. (a) Clania variegata, *Snell.*

The Bag-worm.

References.—*Hampson, Fauna British India (Moths), Vol. I., 291 ; Dudgeon, Ind. Mus. Notes, Vol. II., 63-67, 157 ; III. (pt. 3), 111-112 ; IV., 41 ; Cotes, Ins. and Mites, etc., 15.*
(*Reg. No. 53, tube No. 25.*)

Bag with Leaves and Twigs Attached.

365. History.—It is a little difficult to be certain as to what is meant when a writer speaks of a bag-worm with fragments of leaves and twigs attached to it. From the greater prevalence of **C. variegata** in Assam, as compared with **Amatissa consorta**, it might be safe to assume the former, and not the latter, was meant. Thus Mr. Peal (*Tea Cyclopædia, 36*) speaking of the Psychids found by him in Assam, says, " One that feeds on tea makes the case of small pieces of leaf, which it also feeds on. " A Cachar planter referring to Mr. Peal's account of these pests, remarks that one " is unfortunately very common on some gardens in Cachar. It constructs its case of both leaves and small twigs. It grows to a length of about 1½

inches." These and such like descriptions may, for convenience, therefore, be accepted as applying to this species. **THE BAG-WORM.**

We have, however, no difficulty in agreeing with Mr. Dudgeon as to the species found by him on *sal* trees (**Shorea robusta**), and subsequently on tea in Darjeeling. Mr. Cotes (*Insects ad Mites, etc.*,) reviews Mr. Dudgeon's most admirable paper, but adds no new information, and makes no mention of this pest being found in Assam. Mr. Bamber remarks that it "has been said to defoliate tea, but does not do much damage." It would, therefore, seem desirable that I should at once remove any further uncertainty as to the existence in Assam of this one of the most general of the Psychid tea pests. I found it everywhere both on the south and the north bank gardens. In one garden, where I chanced to be on a visit, great basketfuls of the dirty grey bags were being brought in daily and destroyed. **Prevalent in Assam.**

366. Description.—During the larval stage this insect has generally one or two entire leaves, and perhaps a twig or two loosely attached to it *throughout their length*, and thus resting flat on the surface of the bag. When mature, the larval case may be said to be 2½ to 3 inches long, and the worm, when walking or feeding, is seen to have a protecting silken mantle within which it withdraws on being disturbed—the mantle being gathered together around the mouth of the bag. It has no operculum-like lid such as has been mentioned in connection with the faggot-worm. In the chrysalis state the protecting leaves are for the most part dispensed with, and all that remains is the impression of the leaves that had once been attached by their surfaces to the silken bag. In this respect the present species differs materially from **Amatissa consorta**, since in that insect many leaves, or only fragments of leaves, *are attached by their lower cut edges*, not by their surfaces, so that the blades of the leaves on drying curl up and give a scaly appearance to the basket-worm **Amatissa** not seen in the present insect. The chrysalid-bags are attached to twigs by a fold of silken material, thrown round as in the *tasar* silk-worm. The female bags are much larger, or rather more swollen, than the male. Mr. Dudgeon tells us that the eggs are laid about the 7th of March, and that the larvæ emerge on the 1st April. This he regards as the first brood, but he was unable to ascertain how many broods there were during the year. **Difference between the Bag-worm and the Basket-worm.** **Eggs Laid in March.** **Information Required.**

Lepidoptera (Psychidæ).

CLANIA VARIEGATA.

367. Depredations.—A tea planter writing of what I take to be this species (if not certainly of Amatissa) says, that "instead of attacking only the leaves of the tea plant, it attaches itself to the stems and lower branches, from which it eats away the bark, when, of course, the upper part of the plant attacked dies off. On some gardens, at certain times in the year, the injury caused by this larva is very great, and children are frequently employed for days together in picking them off the plant." (*Tea Cyclopædia, 39.*) The above account corresponds very closely with my experience, but, as already indicated, there is very little to distinguish the action of this pest from that of Amatissa consorta.

Collection of Bag-worms

368. Remedy.—There is but one thing that can be done, namely, to collect all the bag-worms found and to destroy them. If this be systematically accomplished, there need be little fear of the occasion ever arising when more severe measures would be indicated.

SPIRAL FAGGOT-WORM.

18. (c) Clania holmesi, *sp. nov.*

The Spiral Faggot-worm.

(*Reg. No. 54, tube No. 205.*)

Occasional in Assam.

369. History.—The insect which I desire to allude to in this place is one which I found here and there all over the tea gardens of Sibsagar district, though nowhere very abundant. A fairly good supply of live chrysalides was sent me the other day from Nigiriting, from which I hope in due course to obtain the moth. If the suggestion of its genus here given be correct, I would venture to propose the above name for the species in honour of my friend Mr. A. B. Holmes of Nigiriting. While exhibiting my collection of tea pests, to an old and experienced Cachar planter, he at once picked this out as the common faggot-worm of that district. He informed me that he was in the habit of getting the children to collect a quantity for him when he contemplated going to fish—the worm, when cut out of its faggot-case, was, he informed me, excellent bait. If this evidence be accepted, then it would appear that this should be regarded as more especially the faggot-worm of Cachar, taking the place in that district of the Assam species I have provisionally described above, under the name of Clania crameri.

Common in Cachar.

Short Twigs Used.

370. Description.—The largest samples of the spiral faggot-worm, in my possession, do not exceed 1½ by ⅛ an inch. The little sticks of

The Spiral Faggot-worm.

which the case is built, are cut uniformly to lengths of from $\frac{3}{8}$ths to $\frac{1}{8}$ths of an inch. The longer ones are used at the lower extremity, and the shorter at the upper. They are placed parallel to each other, but slightly sloping across the main axis of the larval case, so that they form a complete spiral of four coils. When extended out of its spirally constructed house, the little yellow caterpillar, with one brown spot on each of its body segments, is seen to be surrounded by a large open mantle. This consists of a dull grey silken membrane, studded with chestnut coloured minute specks. **SPIRAL FAGGOT-WORM.**

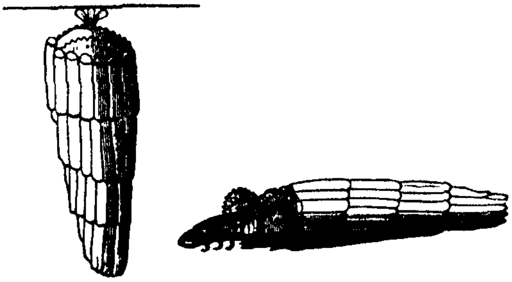

FIG. 6.—THE SPIRAL FAGGOT-WORM.

The accompanying sketch represents life size the caterpillar when feeding and also when suspended in the chrysalis condition.

371. DEPREDATIONS AND REMEDY.—In these respects this insect does not seem to differ in any essential from the species (Nos. 16 and 17) described above, and should, of course, be eradicated at the same time that other Psychids are being collected. **Collection and Destruction.**

19. (a) Amatissa consorta, *Templ.*

THE BASKET-WORM: *Barota*, KANGRA, *Batea bunda puk*, (HOUSE-FORMING CATERPILLAR), ASSAM. **THE BASKET-WORM.**

References.—*Hampson, Fauna British India (Moths), Vol. I., 292; Journ. Agri.-Horti. Soc. Ind., Vol. V. n.s. Proc., 21st June 1877, xxxi; Tea Cyclopædia, 55; Ind. Mus. Notes, Vol. III., 111; Cotes, Insects and Mites, etc., 16.*

(*Reg. No. 12, tubes Nos. 79, 154 and 249.*)

372. HISTORY.—Some doubt exists as to the passage in the *Agri.-Horticultural Society's Journal* and the one in the *Tea Cyclopædia* (quoted above) having reference to this insect or No. 26 below. The young larvæ of **Amatissa** are remarkably similar to the

AMATISSA CONSORTA.

mature larvæ of the species of **Psyche** there described. I am inclined, however, to believe these passages do refer to this insect more especially as they imply that it ultimately forms a large cocoon with leaves attached to it.

Found in Assam and Kangra.

It was reported in 1893 to have appeared as a tea pest in Darjeeling, but in his *Insects and Mites, etc.*, **Mr. Cotes** makes no mention of any other occurrence of this insect. It was found by me in Kangra (more especially at Holta) during November 1894 in the young larval active stage and also as empty cocoons. It was next re-discovered by me in Assam, more especially abundant in the Sibsagar district. But there was one point of difference between the two collections—the larvæ seen in Kangra in November were not a third the size of those picked up in April and May in Assam, while at the same time the Kangra chrysalid-cases were on an average twice the size of those found in Assam. I sent samples of both these collections to **Mr. Green** with the above remark, and specially asked whether he thought the Assam form might be a distinct species. He very properly replied that the larval cases of so many of these insects are alike, and vary also to a certain extent within the limits of the species, so that without seeing the perfect insect it was impossible to be certain.

From these facts, however, it may be accepted that **Amatissa consorta** is a tea pest by no means confined to Darjeeling.

Cocoons Covered with Leaves.

373. Description.—Under **Clania variegata** I have already alluded to the (*barota*) or basket-worm, and need hardly give other particulars. The figure given by **Mr. Cotes** is not a very happy one. Instead of being thatched with irregular elongated fragments, like bits of grass, (*p. 16 of Insects and Mites, etc.*,) the chrysalis-case should be clothed with tea leaves each united by their lower extremities, the upper halves being free and spreading or curling outwards from the bag. Full-grown chrysalid-cases are about 1½ inches long and nearly as broad at the lower extremity.

Caterpillars.

The caterpillars, shortly after they emerge from the eggs, cover themselves with a few minute pieces of tea leaf, but attached in the manner already mentioned, namely, by one end, the other being free. They are at first conical little houses standing on the flattened base, and not more than a quarter of an inch in size. At this stage they are very dangerous and spread all over the bushes, in such numbers that they may be said

to ultimately ruin the entire foliage of the bush, and then take to the bark. As they grow larger, however, they seem to be less voracious, and doubtless a great number get destroyed. After a time at all events they very nearly disappear. One or two large ones may be discovered in the very centre of bushes, comparatively speaking, not at all eaten by them. The chrysalid houses are suspended by the apex to twigs and are to be found right in the heart of some densely foliaged bush.

THE BASKET-WORM.

374. Depredations.—There is one striking peculiarity, not as yet mentioned by me, regarding this insect, it seems to appear at isolated positions all over the estate. The chrysalid-cases, hung up within the bushes, give birth to a countless visitation of minute caterpillars. These completely destroy every leaf of that and of the next one or two bushes, and then disappear for a time, the nucleus of a future generation being carried to some little distance before being hung up in the way indicated.

Appears at Isolated Places.

375. In the passage to which I have alluded, as given in the *Agri.-Horticultural Society's Journal* (contributed by Messrs. Balmer, Lawrie & Co. in 1879) the bite of the caterpillar was supposed to be poisonous to the tea. The passage may be here quoted:—

Bite said to be Poisonous.

"The leaves he prefers to feed upon are of a medium age, but the stems on which he feeds are always of new growth. The leaves he eats holes in, but does not wholly devour. The stem he only eats bark of, but leaves and stems, without exception, die. His bite seems to be very poisonous, as I have seen a stem about 9 inches in length and from which he had only taken a very small piece of bark, rot completely off." The writer in the *Tea Cyclopædia* speaking of a tea garden in Mungledye, says, his first knowledge of this pest was when he found "several hundreds of bushes had been killed and many thousands attacked. I found on talking the matter over, that, in the previous year, many trees were attacked, and some died. Nothing more was done to prevent the increase; however, the following year soon showed how they multiplied." "All hands were called out and work stopped, and these little cages or cocoons containing the caterpillars were picked off." "The insect is generally to be seen hard at work in April." "My native establishments were all instructed to examine any bush attacked, and report it to whoever was in charge. The mere fact of their eating the bark kills

Kills the Plants.

Larvæ Appear in April.

Eats the Bark.

AMATISSA CONSORTA.

Collar pruning Recommended.

the limbs and leaves, and, if allowed to go on, the tree soon follows, but not from their bite being poisonous. If by chance trees should have been attacked, and look dead in the upper part, the best plan is to cut the tree down to the ground, when it will spring up again, if there should be any vitality left in the shoots: by always doing this, you have a chance of saving the bush before all life is out of it."

"When a tree has been badly attacked, so as to be nearly abandoned, the stem and limbs show a light brown appearance.

Burning Preferable.

376. REMEDY.—Should the insect here dealt with appear in a garden, the proper way to deal with it is to at once get dry straw and fire the one or two bushes seen to be invaded with the countless hordes of the minute caterpillars. Having done this a careful search within a radius of, say, 20 to 30 feet all round should be made for any of the large leaf-encased basket-worms. These should be systematically picked off and destroyed. Burning the bushes, is the only effectual cure and, as a rule, would be found preferable in point of time to collar pruning. If not seriously injured, the bushes will recover quite as early, if not earlier, from firing than from collar pruning, and the risk of the caterpillars being shaken off and distributed over other portions of the estate is obviated.

Prompt Treatment Necessary.

This is not a pest that should be trifled with, for, if it be once allowed to get a firm hold of an estate, acres of tea may be killed before anything can be done: promptitude, as with all other pests and blights, is of vital importance.

20. (a) Acanthopsyche (Œceticoides) bipars, *Wlk.*

References.—*Hampson, Fauna British India (Moths), Vol. I., 293.*

377. HISTORY.—Under the name of **Govisana bipars**, *Wlk.*, Mr. Cotes (on the authority of Mr. Dudgeon) gives this moth as a parasite on tea in the Darjeeling district. "Dudgeon noticed that it completely strips the tea bushes it feeds on, and often kills them by taking off the bark to make its case." So far as I can discover, this insect is not met with in Assam, but I would venture the suggestion that it is possible there may have been some mistake in the determination of the Darjeeling pest referred to, since Sir George Hampson mentions only Bombay as a locality for the species in question.

21. Acanthopsyche reidi, *sp. nov.*

LIMPET CATERPILLAR.

THE LIMPET CATERPILLAR.

(*Reg. No. 52, tube No. 110, botanical specimens No. 11198.*)

378. HISTORY.—I can find no mention in books or reports of this, perhaps the most dangerous of all the Psychid caterpillars. The specific name suggested for it is in honour of Mr. George Reid of Melang. The trivial name—Limpet Caterpillar—is expressive of the manner in which this remarkable insect fixes itself to the *upper surface* of the leaves of the tea plant. Though seen in one garden only to an alarming extent, I found this curious insect here and there all over the Assam tea gardens. Samples were forwarded by me to Mr. Green, and I have been favoured with the following reply. "I do not recognize this particular species, though we have some very like it. The larvæ of **Acanthopsyche rhabdophora,** *Hmpsn.*, and **Acanthopsyche plagiophleps,** *Hmpsn.*, and **Acanthopsyche subteralbata,** *Hmpsn.*, riddle the tea leaves in different parts of Ceylon, but I have not experienced such complete destruction as you describe."

Ceylon Allied Forms.

379. DESCRIPTION.—The larval cases of this species might almost be described as small thorns about an inch long, of a dull grey colour, pointed at the apex and slightly and suddenly widened below into a circular sucker-like mouth. They do not carry fragments of leaves or sticks attached to them, but are perfectly smooth. As stated these caterpillars attack the upper surface of the leaf and eat circular spots about an eighth of an inch in diameter, each of which has a tiny speck of epidermis left in the centre. They move from place to place until they reduce the leaf to a mass of thin brown membraneous blotches that correspond to the dead under epidermis. But the leaf is not perforated right through. The time occupied to eat the tissue of the leaf from each circular spot is about five minutes. After the leaves and buds have all been destroyed, they attack the bark and similarly eat away circular spots all over it. When seen on the twigs and branches, they can hardly be recognised since they are of the identical colour and shape of abortive twigs. Indeed the bush, when invaded with this pest, looks like a thorny plant; it has a countless multitude of these most destructive creatures all over it, and within a few weeks it is killed.

Thorn-like Larval Cases.

Leaf not Perforated.

Bushes Killed.

ACANTHOPSYCHE.

Perforates the Leaf.

until they may be ¼ inch in diameter. It does not, however, seem very particular as to its food, and some live caterpillars sent to me from Assam the other day, have taken very kindly to rose leaves.

385. REMEDY.—Hand-picking the caterpillar-cases and cocoons seems the only cure; this should, however, be done systematically so as to save the necessity of more severe methods of treatment.

23. (c) Acanthopsyche *sp.?*

(*Reg. No. 28, tube No. 189.*)

386. This might be described as a very much larger form of the preceding, the larval case being nearly 1½ inches long and bearing a good few short twigs loosely attached. The caterpillar, when feeding, is seen to have a double mantle, one within the other. It feeds on the under surface of the leaves and penetrates right through very similar to No. 22 only, that in Jaipur, where I found this insect, I was told that it also attacked the bark and sometimes does considerable injury.

24. (c) Acanthopsyche *sp.?*

(*Reg. No. 56, tube No. 134.*)

387. I have ventured to place this, as also the preceding form, under the genus **Acanthopsyche,** more as a matter of convenience than actual knowledge of their true position. Externally they bear certain resemblances to No. 22, and perforate the leaves in the same manner. The present form is the largest of the three, sometimes becoming 2 inches long and having a few fragments of leaves and abortive flower buds attached to the larval-case. This last fact is somewhat striking, as I have never seen flower buds woven into the Psychid larval-case of any other species save this one. The caterpillar, when feeding, is seen to have only one protecting mantle, and that very irregular in form.

The insect eats large holes in the leaves and also does considerable damage to the bark, but it is fortunately rather rare. I found it at Moaband, Nigiriting, Golaghat, etc.

25. (a) Acanthopsyche subteralbata, *Hmpsn.*

388. **Dr. A. R. S. Anderson** has kindly permitted me to examine a specimen of the Psychid caterpillar that appeared in Chittagong and did much injury to tea. It is considerably smaller than No. 22

above, but has a very much longer suspending cord. This insect, **Mr. Green** informs me, has been found on tea in Ceylon.

CONICAL PSYCHID.

Other Unidentified Psychids.

There would appear, however, to be several Psychids of this and allied genera on tea that do not appear to have been investigated nor named. I have, for example, in my collection of Assam species one that seems to resemble the Chittagong form. It is in point of size intermediate between Nos. 21 and 22 above.

Then again, I have had sent me from Golaghat a perfectly smooth Psychid larval-case, quite distinct from any of the above and about 1½ inches long. It will thus be seen that my enumeration of the species found in Assam is possibly a very incomplete one.

26. (c) Psyche assamica, *sp. nov.*

CONICAL PSYCHID.

THE CONICAL PSYCHID.

References.—*Hampson, Fauna British India (Moths), Vol. I. (account of genus), pp. 297-300.*

(Reg. No. 58, tubes Nos. 90, 130, botanical specimens showing destruction of the plant No. 11333.)

Perhaps the most Dangerous of Psychids.

389. HISTORY.—I can find no mention in the literature of tea pests of this very destructive caterpillar unless it be found that the passages from the *Journal Agri.-Horticultural Soc. of Ind.* and the *Tea Cyclopædia,* quoted above under **Amatissa consorta,** should be transferred to this position. In some respects I am inclined to think that may be likely, but in any case the destruction there detailed might be said to be true of both these species. The present insect was found by me for the first time at Moaband, but subsequently very nearly all over Assam. It was on one occasion found to an alarming extent, still it exists very nearly everywhere and may, when least expected, assume gigantic proportions.

Attachment as in Limpet Caterpillar.

390. DESCRIPTIONS.—In some respects this closely resembles, in its mature state, young larval cases of **Amatissa consorta.** The fragments of leaves bound to the comminuted case are smaller and more firmly held in this insect than in **Amatissa.** The case is, moreover, more compact in structure, and might be described as an example of a very short and greatly dilated limpet caterpillar-case with a few fragments of leaf and bark adhering. It attaches itself in the same sucker-like fashion, and has for this purpose a soft disk-like rim surrounding the mouth. Within this a diaphragm stretches across (? the mantle very possibly of previous descriptions) which is perforated near

Lepidoptera (Pyschidæ).

PSYCHE ASSAMICA.

the middle by a small opening through which the head of the caterpillar escapes when feeding. The accompanying rough sketch, natural size, represents a leaf showing two of the caterpillars feeding on one side of the leaf; several patches representing portions of the leaf already devoured, on the other; also a pupal case from which the moth has escaped appears suspended from the leaf. On the margin have been given a larval-case (*a*) to show the sucker-like rim, the diaphragm across the mouth, and the little hole through which the caterpillar comes when feeding; (*b*) the chrysalis-case showing the manner in which the diaphragm is drawn out, making the structure biconic when hung up in the resting stage. A sample of this insect was sent by me to Mr. E. E. Green, of Ceylon, who has been good enough to invite my attention to Moore's illustration of the chrysalis-case of **Psyche albipes** (*Lep. Ceyl., II., pl. 118, fig. 4a*). That insect is certainly very much like the Indian insect, but apparently very much larger. For the present, therefore, I prefer to retain this as possibly a new species and suggest a name for it as a matter of convenience.

Appearance of a Leaf Attacked by the Conical Psychid.

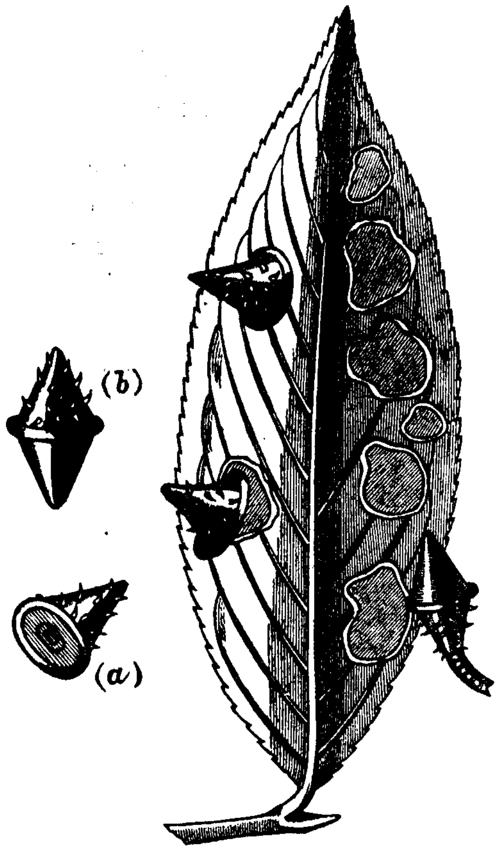

FIG. 8.—THE CONICAL PSYCHID ATTACKING THE *under surface* OF THE LEAF.

391. DEPREDATIONS.—There is very little to say regarding this insect further than I have already stated under No. 21. Its action is precisely similar, and the death of badly affected bushes equally certain. But there is one curiously dissimilar feature. While the limpet caterpillar operates on the upper surface and eats the tissue down to the under epidermis, this insect (which for convenience I have called the Conical Psychid) acts in the opposite direction. It eats the *under epidermis and tissue of the leaf* through to the upper epidermis. By neither of these insects, however, is the leaf perforated through as No. 22. There is also another point of difference. By the limpet caterpillar perfectly circular holes are eaten, each independent of the other; by the conical caterpillar the portion eaten is gradually widened into irregularly shaped patches—in other words the insect eats its way forward instead of moving from spot to spot. CONICAL PSYCHID. Operates on the Under-Surface of the Leaf.

This then is a more difficult pest to recognize than even the limpet caterpillar, since it can only be seen on the under side of the leaves. But in both these instances pale yellow spots all over the leaf, corresponding to remaining epidermis, are visible enough, and should instantly suggest the presence of either of these Psychids. Difficult to Recognise.

392. REMEDY.—It would obviously be impossible to pick the caterpillars off the bushes when once this pest has been allowed to be securely established. There is only one cure, to fire all affected bushes. But the moment this or any of the smaller Psychid caterpillars are seen, children should be at once sent to the affected bushes, and every specimen met with carefully picked off and destroyed. Firing bushes is a necessity due to neglect to check in their early stages the advances of these enemies. Fire the only Effectual Remedy.

LVI.—Wood-boring Caterpillars.

Family COSSIDÆ.

27. (a) Zeuzera coffeæ, *Nietner.*

THE RED BORER. THE RED BORER. *Conf. with para. 46(5).*

References.—*Hampson, Fauna British India (Moths), Vol. I, 312; Journ. Agri.-Horti. Soc. Ind., IV. n. s. Proc., 27th March, 1873, p. xv; 5th Feb. 1874, x; S. E. Peal, in Tea Cyclopædia, p. 35; Nietner, Enemies of the Coffee Tree, 14; Bidie, Report of the Ravages of Coffee Borer; E. E. Green, Insect Pests of the Tea Plant, pp. 8-12, Plate 9; Bamber, Chem. and Agri. Tea, 243; Ind.*

Lepidoptera (Cossidæ).

ZEUZERA COFFEÆ.

Mus. Notes, Vol. I., 198; II., 157; III., 1; IV., 41; Cotes, Ins. and Mites, etc., Tea Plant in Ind., pp. 8-10; Agricultural Ledger No. 27, 1896, p. 3.

(*Reg. No. 41, tubes Nos. 81, 126, 317.*)

Occurs throughout the Tea Districts.

393. History.—It would appear that, of Indian writers Mr. E. L. Edgar, of Cossipore Tea Garden, Cachar, was the first to draw attention to this tea pest (1873). Mr. S. E. Peal (Sibsagar district, Assam) seems to have next come forward with useful particulars. Mr. E. E. Green, (*Insect Pests of the Tea Plant*) of Ceylon, furnished a long and instructive description of the insect and its ravages. Mr. Bamber mentions it as tunnelling "the stems of tea bushes in Ceylon and Cachar." In March 1891, Messrs. Andrew, Yule & Co. sent specimens from Jorhat (Assam) to the Indian Museum (*Ind. Mus. Notes*). Mr. Cotes (*Insects and Mites, etc.,*) mentions that samples had been furnished to the Museum by tea gardens in Darjeeling. It was collected by me in Sibsagar, Dibrugarh, and North Lakhimpur, and samples were sent me for identification by the Indian Tea Association (October 1895) from a garden in Cachar; also by the Burma Government from the wild tea of the Shan States. (*Tube No. 126.*)

It may thus be accepted that this pest occurs practically throughout the India and Ceylon tea districts.

Boring Caterpillar.

394. Description.—The boring caterpillar, when cut out of the branches, is found to be of a red or orange colour, and to be from 1 to 2 inches long. The head is small and horny. The adjoining segment is swollen and protected by a blackish-coloured plate; there is also a similar plate at the anal extremity. On attaining maturity, it constructs within its tunnel a small chamber, and there it changes into the chrysalis. "The moth is a remarkably pretty insect with translucent white wings, the upper pair marked with numerous metallic steel-blue spots and bars. The legs are deep shining blue, while the body is thickly clothed with white hair looking like fine cotton wool" (*Green*). Mr. Bamber says that "The full-grown caterpillar can be found about December, after which it changes to a moth, which appears in March. The period actually spent in the larval stage has not, however, been satisfactorily made out. It is more than likely that it lives for over one year. Green tells us that he has seen the moths at several other times of the year than February—the month fixed by Nietner.

Moth Appears in March.

The Red Borer.

395. Depredations.—Mr. Green says, that the female moth is provided "with a long hard ovipositor, with the help of which the eggs are deposited in crevices of the stem. The young caterpillar gnaws its way into the wood, choosing at first small shoots, adapted to its size, and bores a tunnel along the inside. It completely devours the pith and inner wood, leaving a thin outer shell just sufficiently strong to support the branch. From the small shoots the borer, as it grows, eats into the larger branches and stems. I have seen a two-year old tea plant with the stem completely hollowed out from about 3 inches above ground to the ends of the shoots. The presence of the grub may generally be detected by the small round pellets, like conglomerated saw-dust, the excreta of the insect, which accumulate at the foot of the tree."

THE RED BORER. Eggs laid by Ovipositor.

The Larvæ Enter at first Small Shoots.

Presence Detected.

"Young plants are killed down to the ground, and may or may not throw out fresh shoots. In older bushes, one or more of the main stems only will be affected: the dead leaves on such stems will show where the borer is at work, for they do not fall off as in some other diseases, but dry up and remain fixed in their original positions."

Dead Leaves Indicative of Action.

Mr. Peal remarks that "it causes more damage in proportion than caterpillar: * each individual, ere killed, generally destroying a plant or branch. It is fortunate that they are not found in larger numbers." Mr. Bamber says, "They chiefly attack young bushes, but have been seen in plants up to 18 or 19 years of age."

396. A Cachar planter, from whom I obtained a specimen (through the Indian Tea Association), writes that borer "is here comparatively common, as you will perceive from the samples. It attacks the strongest and healthiest shoots of indigenous bushes, causing the shoots to wither and eventually rot off just where the borer commenced. The grubs live on the pith of the shoot. The borer does not commence from the ground, the shoot I enclose rotted across about 2 feet from the ground, the pith of the lower portion being intact. I think many cases that are put down to white-ants are really the work of this borer."

Common in Cachar.

Borer Works Down.

397. In my experience (more especially in North Lakhimpur), the borer attacks indiscriminately old and young tea. It bores right

* In Assam the term "Caterpillar" is generally used to denote *Andraca bipunctata*, and it is in that respect that Mr. Peal uses it above.

Lepidoptera (Limacodidæ).

ZEUZERA COFFEÆ.

Should be Looked for while Pruning.

down, sometimes into the roots, so that even in collar pruning it can be cut out with difficulty. The prevalence of this pest can generally, however, be seen at the pruning season, as it certainly commences on the young shoots and works downwards. The "snags" formed while pruning on to last year's wood, are often seen to be rotten in the centre, because the borer had been at work within. When such branches are exposed in pruning, the section gives direct entrance to white-ants and other pests.

Pruning off Affected Twigs.

398. REMEDY.—Mr. Peal very correctly says, "Preventative cure there seems none, and all we can do is to carefully cut down and destroy every individual found." But as part preventative, the moth should be hunted for and killed, thus, if possible, preventing them from laying eggs. Mr. Nietner tells us that at one time the borer was so prevalent in one of the districts of Ceylon, that coolies were sent out to hunt the insects and used to collect several bottles full daily. The coolies in hoeing should be offered a reward for every tree that they detect with the characteristic heaps of excreta around the stems. In pruning, orders should be given when the section is seen to be rotton in the centre to cut lower and still lower until entire wood is found. In this way the young larvæ will be prevented from continuing their ravages. It is in any case dangerous to leave exposed to the weather sections of stems, branches, or twigs that are rotten in the centre. White-ants will at once go for such wood, and it may subsequently be difficult to say whether the original depredator was borer or white-ant.

LVII.—Slug-like Stinging Caterpillars.

Family LIMACODIDÆ.

SLUG-LIKE STINGING CATERPILLARS.

Conf. with para. 46(6).

399. The moths to which it is here desired to draw attention may be said to constitute the family known as the LIMACODIDÆ.

They have greenish yellow thick slug-like caterpillars, which at first sight would seem to possess neither mouth nor feet, since these are often retractile. These caterpillars are, moreover, as a rule, more or less elliptic oblong in outline and have frequently a series of dorsal warts arranged lengthwise that bear on their apices stinging or urticating hairs. Occasionally, however, they are smooth, semi-transparent (devoid of warts or stinging hairs) elliptic and convex creatures that look not unlike little patches of jelly adhering to the tea leaves.

Stinging Slug-like Caterpillars.

STINGING CATERPILLARS.

The blister caterpillars are extremely sluggish in their movements, and during day time do not seem to feed. Fortunately they are not, as a rule, prevalent. So far as my personal experience goes, they were never shown to me as anything more than "nasty poisonous slugs that often cause severe blisters on the women's fingers, when sufficiently abundant to be repeatedly touched accidentally." I am, however, aware from reports that have been published regarding one or two tea gardens, both in India and Ceylon, that these very caterpillars have been known to appear in such vast numbers, as not only to defoliate many acres of tea, but to render it impossible for the work-people to enter the invaded portions of the estates. The caterpillars of certain species drop to the ground in order to pupate, and the work-people treading on them with their naked feet, get sores sufficiently painful to incapacitate them for a few days, or even invalid them for considerable periods. Sores on the sole of the foot are not by any means easily cured.

Pupate in the Ground.

It will accordingly be recognised that a family of pests of this nature should not be ignored, but, on the contrary, kept well in hand. It may, therefore, be desirable to mention the species of this family of tea pests that have been authenticated, and, where possible, record my own personal observations under each, as also to give some brief account of those not as yet identified by the entomologist.

28. (a) Thosea cotesi, *Swinh.*

References.—*Hampson, Fauna British India (Moths), Vol. I., 380; Indian Mus. Notes, Vol. II., 36-37; IV., 41; Cotes, Insects and Mites, etc., 11-12.*

400. History.—Full particulars of this insect will be found in the works mentioned above. It may be here stated, however, that it was first discovered in Darrang and communicated to the Entomological Department of the Indian Museum by Messrs. Williamson, Magor & Co. The caterpillars defoliate the bushes and then descend to the ground where they roll themselves into the characteristic Limacodid pupal case, which resemble minute potatoes. "Children had been employed to hand-pick the caterpillars, but the numbers of the pest have been too great to be successfully dealt with in this way, and some inconvenience was also found owing to the stinging properties

Defoliates the Bushes.

Pupal Cases like Little Potatoes.

THOSEA COTESI.

of the bristles with which the caterpillars were armed." The full-grown caterpillars sent to the Indian Museum in January appear to have transformed at once into cocoons, since we are told the moths emerged on the 26th January. From this circumstance Mr. Cotes infers that "from its activity in the coldest month of the year and the short period spent in the pupal stage, the insect would seem likely to pass through a number of generations in the year, but more extended observations are required."

401. OBSERVATIONS IN ASSAM.—At a garden visited on the 8th April (in the Moran section of the Sibsagar district), I found the moths of what I took to be **Thosea cotesi,** but not having an insect net by me at the time, could not secure any. They were of a rich brown colour, the lower wings almost black. The garden may be said to have swarmed with them, and I was surprised at the long period they rested perfectly quietly on the tops of the leaves, basking as it were in the sun, but most probably depositing eggs. On being approached, they jumped or rather flew off suddenly. I could not, however, discover a limaciform caterpillar on the tea bushes near by, though many hard shell-like cocoons, with circular lid-covered openings, were found firmly attached to the older woody shoots and mostly near the points of branching. These cocoons were between ¼ and ½ inch in length, and when found were very hard, though they broke sharply when pressed. It would of course not be justifiable to affirm, that the moths seen were of the same species as the cocoons, the more so since it is said the cocoons of **Thosea cotesi** are formed on the ground, and not on the tea bushes.

Cocoons Formed on the Twigs.

I have not heard whether the garden in question had, subsequent to the date of my visit, a more than ordinary visitation of the greenish yellow slug-like stinging caterpillars of this species.

29. (b) Thosea recta, *Hmpsn.*

References.—*Hampson, Fauna British India, (Moths) Vol., I., 378 ; Indian Museum Notes, Vol. IV., p. 56, plate 1.*

A Ceylon Leaf Defoliator.

402. HISTORY.—This new tea pest, like many others, was first discovered by Mr. E. E. Green. According to his correspondent (Mr. W. D. Holland, of Balangoda, Ceylon) it had completely defoliated the bushes over several acres. A similar statement of the dangerous nature of this new pest was furnished by Mr. Willisford, of Black-water Estate (Ceylon), where it had stripped 50 acres of tea.

403. DESCRIPTION.—The caterpillars of this insect are very much like the typical form of the family already described, except that they are said to have "a quadrate saddle-shaped spot occurring on the middle of the back; a chain of smaller red spots on the medium line in front, and two or three similar spots behind." GREEN STRIPED NETTLE-GRUB.

A caterpillar, very similar to the above description, I recollect seeing once or twice, so that it would be no great surprise to me were **Thosea recta** found in Assam; so far as known at present, however, this pest is confined to Ceylon.

30. (c) Thosea divergens, *Moore.*

THE ASSAM BROWN AND GREEN STRIPED NETTLE-GRUB.

References.—*Hampson, Fauna British India (Moths), Vol. I., 380.* (*Reg. No. 37.*)

404. HISTORY.—During my explorations in Assam I repeatedly came across a limacodid caterpillar that differed in many respects from the description and figure given by **Mr. Cotes** of **Parasa lepida.** At the same time I failed to discover that species, though I looked with some care for it, since **Mr. Cotes** had assumed that it might very possibly be found in India, as in Ceylon, to be a pest on the tea plant. In the *Indian Museum Notes* (as also in several other publications) mention has been made, on more than one occasion, of a stinging caterpillar, common in Assam. The insect that I propose to deal with in this place as also No. 32 below, are, I believe, the chief stinging caterpillars of the province, though doubtless there may be one or two other species as well. A Common Stinging Caterpillar.

405. DESCRIPTION.—Through the kind assistance of **Mr. W. J. Fleet** I have been able to procure what, I have no doubt, is the perfect insect of one of the commonest stinging slug-like caterpillars.

Mr. Fleet had collected for him at Biswanath some of the caterpillars to which I allude, and feed them out. He obtained cocoons and ultimately the perfect insect as follows:—

Cocoon.—Very similar to that of species No. 32 below; ovate, ⅜ths inch long, opening by a circular lid, smooth, brownish-coloured, formed under ground.

Perfect Insect.—A little over an inch across the expanded wings, of a rich pale chestnut brown colour. Forewings with two dark lines that extend from the costal margin (starting at a point about

Lepidoptera (Limacodidæ).

THOSEA COTESI.

of the bristles with which the caterpillars were armed." The full-grown caterpillars sent to the Indian Museum in January appear to have transformed at once into cocoons, since we are told the moths emerged on the 26th January. From this circumstance Mr. Cotes infers that "from its activity in the coldest month of the year and the short period spent in the pupal stage, the insect would seem likely to pass through a number of generations in the year, but more extended observations are required."

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Cocoons Formed on the Twigs.

I have not heard whether the garden in question had, subsequent to the date of my visit, a more than ordinary visitation of the greenish yellow slug-like stinging caterpillars of this species.

29. (b) Thosea recta, *Hmpsn.*

References.—*Hampson, Fauna British India, (Moths) Vol., I., 378; Indian Museum Notes, Vol. IV., p. 56, plate 1.*

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A Ceylon Leaf Defoliator.

403. Description.—The caterpillars of this insect are very much like the typical form of the family already described, except that they are said to have "a quadrate saddle-shaped spot occurring on the middle of the back; a chain of smaller red spots on the medium line in front, and two or three similar spots behind." GREEN STRIPED NETTLE-GRUB.

A caterpillar, very similar to the above description, I recollect seeing once or twice, so that it would be no great surprise to me were **Thosea recta** found in Assam; so far as known at present, however, this pest is confined to Ceylon.

30. (c) Thosea divergens, *Moore.*

The Assam Brown and Green Striped Nettle-grub.

References.—*Hampson, Fauna British India (Moths), Vol. I., 380.*
(*Reg. No. 37.*)

404. History.—During my explorations in Assam I repeatedly came across a limacodid caterpillar that differed in many respects from the description and figure given by **Mr. Cotes** of **Parasa lepida.** At the same time I failed to discover that species, though I looked with some care for it, since **Mr. Cotes** had assumed that it might very possibly be found in India, as in Ceylon, to be a pest on the tea plant. In the *Indian Museum Notes* (as also in several other publications) mention has been made, on more than one occasion, of a stinging caterpillar, common in Assam. The insect that I propose to deal with in this place as also No. 32 below, are, I believe, the chief stinging caterpillars of the province, though doubtless there may be one or two other species as well. A Common Stinging Caterpillar.

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Perfect Insect.—A little over an inch across the expanded wings, of a rich pale chestnut brown colour. Forewings with two dark lines that extend from the costal margin (starting at a point about

BELIPPA LOHOR.

$\frac{1}{8}$th inch within the apex), and passing across while they diverge toward the inner margin.

31. (b) Parasa lepida, *Cram.*

BLUE STRIPED NETTLE-GRUB.

References.—*Hampson, Fauna British India (Moths), Vol. I., 388 ; Green, Insect Pests of the Tea Plant, 66-71 ; Bamber, Chem. and Agri. of Tea, 244 ; Ind. Mus. Notes, Vol. I., 197 ; Vol. II., 158 ; Cotes, Insects and Mites, etc., 13.*

HABITAT.—This insect is said to be met with throughout India and Ceylon, but, so far as my experience goes, does not occur on the tea in Assam.

406. HISTORY.—It has been recorded by Mr. Green as attacking tea in Ceylon. So far as Indian records are concerned, it would appear to have been found on the mulberry and other plants, *but not upon tea.* Mr. Cotes apparently included it in his *Insects and Mites which attack the Tea Plant in India,* on the assumption that it very possibly would be found to do so. He gives a plate of the moth and its caterpillar taken from Moore, *Lep. Ceyl., Plate 128.*

DIBRUGARH STINGING CATERPILLAR.

Conf. with para. 498.

32. (c) Belippa lohor, *Moore.*

Reference.—*Hampson, Fauna British India (Moths), I., 400.*

(*Reg. No. 83, tube No. 76.*)

HABITAT.—Doom Dooma, Upper Assam.

407. HISTORY.—On the 30th November 1896, Mr. Kirwan, Superintendent of the Doom Dooma Company's gardens, forwarded to me, through the Planters' Stores and Agency Co., Ld., Calcutta, caterpillars that had been doing considerable injury to the tea. He subsequently (29th January) sent a large quantity of the cocoons. He then wrote, "I now beg to state that all the caterpillars have disappeared, and only the shells containing the insects remain. These are found under the bushes about $\frac{1}{2}$ to 1 foot below soil. I am *khurping* all round these bushes, and collecting and burning the shells, by which means I hope to get rid of nearly all, and thereby reduce the pest next season. As soon as the caterpillars appear again, I will collect some and send them to you in all stages. This cannot be done till about October next, as I do not think the caterpillars appear before then."

Cocoons Formed in January.

Caterpillar Supposed to Appear in October—One Brood a Year.

From the supply of cocoons procured as above narrated, a few of the moths were obtained in March and April. These, through the kindness of Mr. Barlow were identified as a species of **Belippa,**

and subsequently by Sir George Hampson as B. lohor. In order that it may be recognized by the planters, it may serve a useful purpose if I attempt to give a short popular description of this insect :— THE COMMON ASSAM NETTLE-GRUB.

408. *Larvæ.*—Mr. Kirwan wrote :—The capterpillars found on the tea leaves appear first as green transparent bulbs with thin skins They are quite round on the back, but have prickles all over them which sting badly if touched. In time they come out of these cases, as active caterpillars, and now commenced to eat the older leaves first but advancing up the twigs devour the younger leaves and ultimately the tips of the shoots. Moths Appeared in April. Eat the Older Leaves First.

409. *Cocoon.*—Apparently only rarely attached to the tea plant, mostly buried under ground. Smooth, dull brown in colour, rotund, with an outer brittle shell and a separable lining of loose brownish-red coloured hairs within. It opens by a circular lid to allow of the escape of the perfect insect. Pupa skin left more than half protruding from the circular opening of the cocoon. These cocoons have been described by Mr. Kirwan as closely resembling tea seed—a very excellent comparison, for in size and colour they can with difficulty be distinguished from medium-sized seed, if viewed at a little distance. But among the large supply furnished by Mr. Kirwan there were found some 20 or 30 that clearly had been formed on the bushes as they had tea leaves firmly attached on two sides. These were also much paler coloured, and from the character of the antennæ of the pupal cases appear to have contained male insects. These, I find, are identical with a dozen or so of empty cocoons picked oft the bushes by me at Moaband on April 27th. Cocoons Buried Under Ground. Resemble Tea Seed.

410. The *Perfect* insects are about 1 inch across the forewings when fully expanded. *Female.*—Head, thorax, abdomen and wings of a light fulvous colour; undulating markings of a darker colour especially near the discoidal cell; near the apex, on the outer margin, there are two minute black spots, and beyond these and projecting from the costal margin a small white band; also two pale-coloured spots on the apex of the cell. Hind wings of a paler and more uniform colour, but with a small black marginal spot at the apex and a still more indistinct one at the anal angle. *Male* considerably smaller than the female, much darker in colour (almost chestnut), but with similar markings and spots. It will thus be seen to differ very slightly from the description given of B. lohor. Description of the Moth.

Lepidoptera (Limacodidæ).

URTICATING CATERPILLARS.

Perhaps the mostdistinctive diffe rence between this insect and the well-known **B. laleana,** *Moore,* lies in the fact of the larvæ being armed with stinging hairs instead of naked, and in the cocoons being dull brown instead of whitish.

Very Injurious to Tea.

411. DEPREDATIONS.—From the account given by **Mr. Kirwan,** this insect appears to do considerable injury to the tea. In his letter of the 20th January, he reported that the caterpillars had disappeared, and, according to his experience, would not re-appear before October.

412. REMEDY.—When it is known that the caterpillars have appeared badly, the ground all over the affected part should be carefully hoed, the tea-seed-like cocoons collected and destroyed. The collection of the caterpillars is no doubt a difficult business owing to their poisonous nature, but, as far as possible, this should be done.

OTHER URTICATING SLUG-LIKE CATERPILLARS.

Other Assam Stinging Slug-like Caterpillars.

413. During my ride through the tea gardens of Assam, I came across two or three other Limacodid caterpillars (or what I supposed might belong to that family) on tea, not prevalent anywhere certainly, but still to be seen here and there all over the valley. I was unfortunately unable to rear these worms, and thus could not procure the corresponding cocoons and perfect insects. I think it as well, however, to give here one or two brief extracts from my diary regarding at least two of the forms that are fairly frequent :—

414. (*A*) At Ligri Pukri I collected a solitary example of a thick orange-red caterpillar which I took to be that of a Limacodid moth, and it was said to be poisonous. Next day (April 12th,) it spun a silken-felt of dark dirty purplish colour across itself, thus drawing at the same time the upper surface of the leaf tightly over it. At Nigiriting on the 2nd May, the same caterpillar was again collected, and an hour after it spun an identical enclosure. It is now two years since these cocoons were preserved, but so far the moths have not appeared. (*Reg. of Cocoons No. 49.*)

On the 3rd of May I again found three more of these Limacodid-looking caterpillars. I made a rough drawing and brief description of them before being preserved in spirit. It may, therefore, be of assistance to give here the descriptive passage then recorded. Caterpillar linear oblong, about 1 inch in length, thick, convex, widest at the middle, rounded at both extremities, and a little over ¼ inch in

URTICATING CATERPILLARS.

thickness. Colour orange yellow. Body indistinctly referred to eleven sections (or Somites as they are called by the entomologist), but back pronouncedly furrowed lengthwise, so to speak, by five rows of pale yellow tubercles, each bearing two strong spreading hairs that became covered with a thick sticky poisonous-looking fluid on the worm being disturbed. Then laterally a row of black circular spots or little mouths one to each Somite, and beyond these a row of tubercles, similar to the dorsal ones, only of a deep orange-red colour. Belly pale coloured, thoracic feet minute, prolegs five pairs (including the anal), and these consisted of curious transverse plates which, like the head, are retractile on being disturbed.

I was assured by the coolies that it was very poisonous, and it certainly had all the appearance of being so; but I held all three worms in my hand for some time, and experienced no inconvenience. It seems thus possible that the poisonous property of the sticky fluid may be spent on the first occasion of its being handled and for some time thereafter it is inert. (*Tube No. 167.*)

A Flat Thin Green Caterpillar.

415. (*B*) At Moaband, on the 27th April I came across another caterpillar that, I believe, was very possibly that of a Limacodid moth. It was a pale green, very thin, flat creature, a little less than an inch in length and nearly three quarters broad. It consisted of a bright yellow central body of eleven sections divided by dark green lines, the body being perhaps ⅛th inch in breadth. From this was spread out all round a thin semi-transparent membrane, traversed by dark green lines (like the ribs of an umbrella), and which extended from the sections of the body until each ended in a long delicate and hairy cuspid which was gland-tipped and exuded a poisonous fluid. The second pair of ribs from the anterior extremity were much the longest, the others being more or less of equal length, but all were ciliate. At first I could find no feet, and thought the creature advanced by moving forward folds of its mantle or flattened body, but after a time I discovered minute retractile feet.

This caterpillar was well known to the coolies to whom it was shown. It was looked upon with repulsion as being specially poisonous, but was stated to be fortunately not very common. I only came across the one here mentioned.

416. In *Conclusion*, it will be seen that there are very possibly at least half a dozen species of Stinging Limacodid Slug-like Caterpillars

GASTROPACHA SP.

in Assam. While these (with one or two exceptions) do very little injury to the tea, they are well worthy of careful consideration both as being capable of doing a fair amount of injury and as sources of much annoyance to the work-people. But there are several instances on record of hairy poisonous caterpillars that do even a greater amount of damage to tea, and these will be found discussed very briefly below under the Family LYMANTRIIDÆ.

HAIRY CATERPILLARS.

LVIII.—Hairy Caterpillars.

Family LASIOCAMPIDÆ.

417. Several moths belonging to this family are known in Europe and America to seriously damage trees and other perennial plants. **Mr. W. F. H. Blandford** (in **Schlich's** *Manual of Forestry, Vol. IV., p. 265*) gives an interesting account of **Gastropacha pini**, a destructive pest on the pine trees of Germany. Another species **(G. quercifolia)** does considerable damage to apple trees. This Lappet Moth has been fully described by **Miss E. A. Ormerod** in her *Report of Injurious Insects for 1894, pp. 1-4.* An insect which doubtless belongs to this family was found by me on three or four occasions but only in the larval condition, so I am unable to name it definitely but think that, for the present, it may be spoken of as :—

LAPPET CATERPILLAR.

33. (c) Gastropacha *sp. ?*

LAPPET CATERPILLAR.

References.—*Hampson, Fauna British India (Moths) I., (genus) pp. 428-29.*

(Reg. No. 17, tube No. 61.)

A Common Large Grey Caterpillar.

418. HISTORY.—On April 12th (at Nahorhabi, Sibsagar District) a very large caterpillar was found on tea and observed to be doing much damage. Specimens were collected and preserved. These were found adhering to dry exposed pruned twigs which, in colour, they closely resembled. They were clearly the larvæ of a lappet moth, in colour, beautifully mottled grey brown with pink markings. They are fully 4 inches long and nearly half an inch thick. Prolegs encased by heavy tufts of downwardly directed hairs, looking like trousers around the feet. The third and fourth, also the tenth somites have these trouser-like tufts with abortive prolegs. On the first and again on the third somite there are dorsal black bands that by the movements of the body may be hid from view or exposed. The

LAPPET CATERPILLAR.

ninth somite has a hump projecting above and the tenth one below. The fourth to eighth somites have pink spots arranged in a single row along the side.

419. **Mr. J. R. E. Geddes**, Superintendent of Nahorhabi, informed me that this caterpillar was sometimes fairly prevalent and did considerable damage. During the day time it was always seen motionless and adhering to the dry twigs which it closely mimicked. At Selang, Jorhat, I found this lappet caterpillar fairly abundant and doing considerable damage. **Mr. Perman** (the Superintendent) informed me that he knew the caterpillar well and had on several occasions found it doing very considerable injury to the tea. At Moaband it was for the third time found and the same information furnished. At Patalipam the lappet caterpillar was again collected, but I was informed it was not known to do much harm.

It will thus be seen that this insect, though so far it has not given any great cause for anxiety, is nevertheless fairly widely distributed over the Assam tea districts. It belongs to a family that are well known to be dangerous enemies to trees, and should on no account be allowed to become established, every caterpillar seen should be collected and destroyed.

Insect not Identified.

One of the specimens that I attempted to feed, spun its cocoon on the 24th April, but a fortnight later some parasitic insect must have escaped from it as the cocoon was found to be perforated. The cocoon was a large loosely formed grey structure arranged on the upper surface of a leaf with one or two leaves brought down on the top of it, also fragments of leaves nipped off and fastened at both extremities of the enclosure thus formed. The material of the cocoon was a felted texture with many grey and black hairs (similar to those on the caterpillar) dispersed through it. A cocoon answering to this description was found by me at Nigiriting, but unfortunately a parasitic fly emerged from it also, instead of the moth, that I had hoped to obtain.

34. (c) Taragama, *sp.?*

(Reg. No. 106.)

420. **Mr. J. A. Thomson**, of Ligri Pukri, Sibsagar District, found the caterpillars of this, as also of the next two species, feeding on tea. They were not sufficiently abundant to be regarded as pests, though

ESTIGENA, SP.

it is perhaps as well that they should be here recorded. The caterpillars were reared in a cage and the perfect moths supplied so that the determinations are very possibly correct.

35. (c) Trabala vishnu, *Lef.*

(*Reg. No. 107.*)

36. (c) Estigena ? *sp. nov.*

(*Reg. No. 108.*)

421. This very interesting insect differs in certain respects from **Estigena pardalis,** *Wlk.*, and is possibly a new species.

Family LYMANTRIIDÆ.

HAIRY CATERPILLARS: SOMETIMES POISONOUS.

422. One of the most striking features of this family (and of the ARCTIIDÆ) is that they have large hairy caterpillars. The hairs, moreover, are utilized by the insect in forming its cocoon. In the LYMANTRIIDÆ many of the genera are also armed with poisonous hairs, so that under this family, in all probability, should be grouped the letters and reports by planters that mention "hairy poisonous caterpillars," as distinct from the short, thick, slug-like urticating caterpillars, already dealt with under the LIMACODIDÆ above.

This passage may possibly refer to Belippa lohor. *Conf with para. 407.*

423. (*A*) The following passage from the *Indian Museum Notes* would seem to be of this nature :—

"From Messrs. Octavius Steel & Co. were received, 11th October 1889, some specimens of a caterpillar covered with urticating hairs. The specimens, though too much decayed for precise determination, were obviously the larvæ of a moth belonging to the group BOMBYCES.

"The following is an extract from the letter of the manager of the tea estate in South Sylhet where the insects were found :—

"'By to-day's post I send you in a bottle a number of caterpillar-looking insects that have been giving me a lot of trouble this year, not destroying the bushes, but laming the coolies. I have sixty coolies incapacitated from work owing to this. The caterpillars, or whatever they are, lie under the edge of the bush, and the coolie treads on them when plucking ; the foot begins to pain, and, if not on the hard sole, a blister rises, and until this forms into a wound and suppurates, the coolie suffers agony and can't walk at all.'"

424. (*B*) A black caterpillar with yellow stripes and covered with poisonous hairs, did much harm on one occasion to two gardens in

the Nowgong District. The following extract from my diary gives particulars regarding that insect:—

HAIRY CATERPILLARS.

The Nowgong Poisonous Hairy Caterpillar.

At Kaliden, visited 17th July, I had some conversation with the Manager (Mr. S. M. Barry) on the subject of caterpillars. He informed me that the one that had done most harm was a hairy worm of a blackish colour with yellow stripes. This appeared in July 1890. It stung very badly and eat the leaves and the bark, thus killing the trees. It began operations at the top and stripped right down. When it first appeared it caused much alarm. Mr. Barry added that samples were sent to the Indian Museum for determination.

Defoliating and Bark eating Caterpillar.

The only mention I can find of the ravages of a caterpillar, in Nowgong District, bearing the date of July 1890, occurs in Mr. Cotes' *Insects and Mites, etc.*, on page 25 but under GEOMETRES. Mr. Barry, to whom I showed the picture of the looper caterpillar there given, at once said it was not the least like the worm to which he referred. It was a hairy poisonous caterpillar, he remarked, that ran quickly and did not loop its body in the manner shown. Mr. Barry permitted me to consult the correspondence that then ensued, and the notes that follow were mainly derived from these papers.

Nowgong Poisonous Caterpillar.

The caterpillars were first seen crossing the roads from the grass lands, in vast multitudes and shortly after every tea bush in the garden was covered. The bushes were beaten with sticks, and the caterpillars killed or trodden into the ground. Their sudden appearance was attributed to an unusual rise of temperature. The Natives know the caterpillar and never sow their *matti-kalai* crop till the pest has passed over. They predicted that it would only last a few days, an opinion subsequently confirmed.

Ate the Bark.

A peculiarity of some interest may be here added. These caterpillars attacked the less vigorous plants and ate the bark even more readily than the leaves. They showed a special favour for "red-rusted" shoots. In 1891 the pest disappeared as suddenly as it had appeared, and has only occasionally been seen since.

425. (*C*) The following passage from the *Tea Planters' Vade Mecum* very possibly alludes to the same insect (B. above). The passage is worthy of being quoted in order to show the extent to which these pests may at times prevail:—

Killed the Bushes.

"About the end of May numerous caterpillars, about an inch long, and of a dullish brown colour, were noticed; but they did not at first

Lepidoptera (Lymantriidæ).

DASYCHIRA MENDOSA.

attack the tea plants. However, they shortly began to do so, eating the bark of the one and two-year old shoots, and causing the plants to die back ; in some cases nearly to the ground level."

" Small low *jat* plants suffered most. At first only a patch separated from the rest of the garden by a road was attacked, but later they spread over the rest of the garden."

" I have only just finally got rid of the caterpillars."

Millions Collected and Destroyed.

" I had millions gathered and destroyed, and in this operation I found that laying down pieces of mango, which attracted large numbers of caterpillars, was of some assistance. In gathering the insects it was necessary to use a small piece of bamboo as a pair of tongs, as the caterpillars induced an itching sensation if touched with the skin."

" This pest has hitherto been unknown in Lower Assam, as far as I can ascertain."

TUSSOCK MOTH.

37. (a) Dasychira (Olene) mendosa, *Hübn.*

THE INDIAN TEA TUSSOCK MOTH.

References.—*Hampson, Fauna British India (Moths), Vol. I., 452 ; Bamber, Chem. and Agri. Tea, 244 ; Ind. Mus. Notes, Vol. II., 43, 159 ; III. (pt. 5), 11, 15 and 42 ; Cotes, Insects and Mites, etc., 21 ; L. O. Howard (under Orgyia leucostigma), Year Book of the U. S. Dept. of Agri., 1895, pp. 368-375.*

(Reg. No. 14, tube Nos. 203 and 228.)

426. HISTORY.—Mr. Cotes had apparently been made acquainted with this as a pest on tea in the Darjeeling District only. It was found by me in every tea garden in Assam. I have, for example, mention of it in my diary in connection with Nazira (several gardens), Moran Sepon, Tiphook, Selang, Noakachari, Badulipar, Golaghat, several gardens in Dibrugarh, Patalipam, Biswanath, Silghat, Tezpur, etc. It may in fact, after **Andraca bipunctata,** be regarded as the most abundant and most widely distributed of all Assam tea pests, although only exceptionally prevalent to such an extent as to occasion very much anxiety.

Most Widely Distributed of all Caterpillars.

Two Forms.

427. I believe that there are two, if not three, forms of this species (possibly distinct species) about equally abundant. At one locality the prevailing colour of the caterpillar is a steel-grey with darker coloured tufts of hairs ; at another, pale yellowish brown with the head and first somite scarlet, the dorsal tufts grey. The latter is perhaps the most abundant and dangerous form.

428. DESCRIPTION.—It is an extremely active little caterpillar and makes off from the bush on the slightest alarm being given. Mr.

THE INDIAN TEA TUSSOCK MOTH.

Mr. Moore's Illustration of the Caterpillar.

Moore's figure of it as reproduced by Mr. Cotes (*p. 21*) will serve at once to identify the insect though it is not good. The two antennæ-like long tufts of hair on the head, as also the erect anal tuft, are each made up of groups of pectinate hairs of different lengths, so that the collective tuft looks as if jointed. Then instead of having what appears like six pairs of prolegs, in the middle of the body, there should only be five pairs. It is possible that one of these supposed pairs of prolegs is intended to represent a tuft of hairs.

429. DEPREDATIONS.—The insect, like most of the members of the family to which it belongs, feeds for the most part during night. At day time the caterpillars hide below projecting corners of clods, in drains, or in rotten portions of the stem. They show a special liking for newly-planted-out tea, both in young gardens and vacancies. It is this feature of the insect that constitutes its chief danger. No person could walk through a garden in Assam without being struck with the remarkable fact, that, along roadsides where there may be young tea bushes, in vacancies all over the estate, or in new extensions, all the old mature leaves of the seedlings have been riddled to pieces. The entire intercellular tissue of the leaf has been eaten away and only a skeleton remains, corresponding to the midrib and veins. The young shoots and tender leaves are rarely attacked.

Prefer Newly-planted-out Tea.

Leaves Skeletonised.

The state of affairs that I have indicated is the work of this remarkably elegant hairy caterpillar, but you may look for days and see no signs of the depredator unless you examine carefully on the ground or return to the affected tea late in the afternoon. The following passage from my diary may be here given as descriptive of the chief peculiarities of this insect:—

430. I went over Tiphook on 21st April with Mr. J. Lawrence, Manager, and was shown some young tea recently planted out where all the older leaves had been eaten to skeletons and few of the younger leaves touched. No caterpillar or other insect had ever been seen feeding on these bushes, though fresh excreta could be found on the leaves, below those perforated. It thus seemed probable that the destruction was caused by a winged insect that came at some fixed time, say at night, and left in the morning. I accordingly suggested that we should revisit that particular new extension late in the afternoon. We accordingly returned at 5-30 P.M. in order

Lepidoptera (Lymantriidæ).

DASYCHIRA MENDOSA.

to try, if possible, to discover the depredator. We had not far to go, the bushes were at once seen to have each one, two or more of the caterpillars of **Dasychira (Olene) mendosa** on them. These were carefully watched for at time, until it was fully established that these were the insects that had eaten out the intercellular tissue of the leaves until only skeletons remained. They were undoubtedly, therefore, the pest we were in search of, and a curious discovery it was.

On hearing us speak, these clever creatures desisted from their feeding operations, and turned their heads up in a curiously threatening attitude as if both on the defensive and offensive. It was further discovered that this remarkably active insect hides in the ground and crawls up on the bushes late in the afternoon, so that it thus feeds mainly at night.

Hairs of the Caterpillar Used in Forming the Cocoon.

431. One cocoon was collected from the plot of young tea, but, though careful search was made, this was the only one seen. This had been spun of grey brown spinose hairs and was deposited on the under surface of two leaves drawn together. The hairs forming the cocoon were seen to be feathered and some of them to end in tufts, exactly similar to those on the back of the caterpillar, only twice as long or more. It would thus appear that the creature produces greatly elongated hairs on its back just before the time of passing into the state of a chrysalis. It cuts these off and builds its cocoon of them, but it must not only elongate the hairs but produce a very much larger quantity than it carries as a caterpillar. Two of the caterpillars reared in the cage produced much smaller and less perfect cocoons to the one collected on tea, but otherwise identical in shape, configuration and structure. (I may here add that on the 15th May an Ichneumonid insect escaped from the cocoon found on the tea bush. (*Tube No. 203.*)

Purposely Selects Young Plants.

432. After having solved the problem of the injury being done to the young tea Mr. Lawrence drove me through a large portion of the garden, not visited in the morning. I found two young plants (filling up vacancies) remote from the new plantation mentioned above, and these were observed to have the leaves similarly reduced to skeletons and to bear **Dasychira mendosa** caterpillars. But though the neighbouring old bushes were carefully searched, none of these caterpillars could be discovered on them. This insect thus shows an inexplicable preference for the older leaves of one or two

year old seedlings, and does much harm, therefore, to new plantation; but it rarely, if ever, attacks old and well-established bushes. THE INDIAN TEA TUSSOCK MOTH.

As the result of this afternoon's study, I was enabled to piece together observations made in many other gardens. I had frequently seen young tea planted out in vacancies or along roadsides, with the older leaves reduced to skeletons, but I could never ascertain the agent of their destruction. The practical inference, therefore, may be said to be that when planters find the leaves of new extensions riddled in the manner described, they should send out the "grub collectors" late in the afternoon, and instruct them to seek for these beautiful, clever, and timid, hairy enemies.

433. REMEDY.—Collect and destroy the caterpillars and cocoons. Where the insect is found to be doing serious damage, it would be a good plan to give the surface soil a good dressing with dry lime and to immediately thereafter hoe the ground. Were this done in the early part of the day, it is probable that a very large percentage of the caterpillars would thereby be destroyed. **Collect the Caterpillars and Cocoons.** **Top Dressing with Lime.**

In Europe **Dasychira pudibunda** (the Pale Tassock Moth) does much damage to the beech, oak, hornbean and alder. Mr. Blandford tells us (Schlich's *Manual Forestry, Vol., IV. 274-277*) that the eggs are laid low down on the stem, about a yard from the ground. The caterpillars hatch in three weeks and make their first meal off their egg-like shells, and thus remain a short time in clusters. They finally ascend and skeletonise the leaves, but do not appear to come down to the ground during day time. In September or October, however, the worms descend to pupate on the ground. The treatment often pursued is to girdle the trees with grease. If done before the hatching of the eggs, this would prevent the ascent of the young worms, and later on check the mature ones from reaching the ground. The suggestion, therefore, might be offered as worth trying, namely, to girdle the stems of the seedling tea plants in the manner here indicated. **Eggs Laid on Stem.** **Pupate on the Ground. Girdling with Grease.**

38. (a) Dasychira, *sp.*

434. Mr. Cotes tells us that caterpillars identified as belonging to this genus were sent to the Indian Museum in 1886, from a tea garden in the Duars, where they were said to have caused serious damage by feeding on the leaves of the tea plant. Mr. Bamber, alluding

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DASYCHIRA, SP.

apparently to this same fact, under the name **D. thwaitesi**, *Moore*, says, that the insect had been "reported as doing much damage by defoliating tea and *sal* (**Shorea robusta**). The *sal* trees throughout 200 square miles of forest in Assam, are said to have been defoliated by it in 1878."

39. (c) Dasychira securis, *Hübn.*

Reference.—*Hampson, Fauna British India (Moths), I., 453.*

(Reg. No. 109.)

435. The caterpillars of this moth were found by Mr. J. A. Thomson, of Ligri Pukri, feeding on tea. A few were collected and reared, and the perfect moths supplied to me. There is, however, nothing further to be said regarding this species than will be found in the foregoing remarks.

40. (c) Dasychira, *sp.*

436. During my explorations in Assam I came across two other caterpillars on tea that, I presume, may belong to this genus. Regarding these the following passages from my diary may be here given :—

Brown Hairy Caterpillar with Blue and Red Markings.

437. (*A*) A caterpillar, apparently a species of **Dasychira**, was found at Sepon on the 15th April—only one being seen. Ground colour brown with blue bands and orange-red spots. Over the third somite from the anal extremity there are two trumpet-like projections that each ended in a sharp red point. Then further up on the next two somites, two sea-anemone-like bodies of a yellow colour, each with a central depression. Over the space between the thoracic legs and the prolegs is placed a large compact tuft of grey-brown hairs that stand erect and connivent into a ball, while on either side of the head are ear-like red elongations. Altogether this is one of the most remarkable caterpillars found on the tea plant, but it had never been observed by any of the planters, to whom it was shown, so that it must be regarded as a rare pest. It belongs, however, to a family well known as crop depredators.

Canary Yellow Hairy Caterpillar.

438. (*B*) A caterpillar obtained along with **D. mendosa**, on the Tiphook young tea : I could find only one or two. It was canary yellow all but a triangular black band. Hairs radiating in tufts from elevated warts. In front of the black mark there was an erect tuft, and on either side of the head exceptionally large tufts of yellow hairs. Feet with cilia. There appeared to be no doubt that it was

related to the caterpillar collected at Sepon, and was thus in all probability a species of **Dasychira** possibly **D. horsfieldi.** HAIRY CATERPILLARS.

41. (c) Euproctis? *sp. nov.*

References.—*Hampson, Fauna British India (Moths), Vol. I., the genus, pp. 471-484.*

(*Reg. No. 85, tubes Nos. 156, 211, 235.*)

439. History.—Through the kindness of **Messrs. Finlay, Muir & Co.**, I had the pleasure to receive, on the 13th March 1897, cocoons and caterpillars of what appeared to be a new tea pest. From the cocoons, three badly formed moths were ultimately obtained. These **Dr. A. R. S. Anderson** was good enough to have compared for me with the collections at the Indian Museum, with the result that they were pronounced to "probably belong to the genus **Euproctis.**" I next sent a specimen of the moth and some caterpillars and cocoons to **Mr. Green** in Ceylon, and he favoured me with his opinion on them, namely, that "it was evidently a species of **Euproctis.**" The specimens had been obtained from **Mr. Harrison**, Manager of Lebong Tea Estate, Darjeeling.

440. Depredations.—It may be worth while suggesting that this in all probability is the black caterpillar mentioned by the author of *Notes on Tea in Darjeeling*. On page 53 he says, it "sometimes clears every leaf off patches of 30-40 acres. This is the larva of a small white moth. It is a black caterpillar about ½ inch long." That brief description corresponds very closely with the material furnished me by **Mr. Harrison** who writes, this is "a new sort of blight. It is a black-brown hairy caterpillar. It attacks the old leaves and strips the trees. It performs all its ravages at night, and hides itself under clods and stones during day. I have boys on catching some thousands daily. They appear on the dry ridges and are not found in any damp hollows. They have stripped the leaves some 50 to 60 acres of an adjoining garden, and are now attacking the bark. On lower portions of Lebong they have now appeared and are doing considerable harm. I fancy they will disappear with rain." Black Hairy Caterpillar. Defoliated 50 to 60 acres.

441. Remedy.—It will be seen that the method of attack and other particulars of this pest correspond in every particular with **Dasychira mendosa** above, and the treatment to be pursued should thus be the same as for that pest.

ARCTIA RICINI.

42. (c) Numenes siletti, *Wlk.*

References.—*Hampson, Fauna British India (Moths), Vol. I., 456.* *(Reg. No. 110.)*

442. This bright orange-coloured little moth is by no means uncommon on tea, though nowhere to the extent to be regarded as a pest.

Family HYPSIDÆ.

43. (a) Hypsa alciphron, *Cram.*

References.—*Hampson, Fauna British India (Moths), Vol. I., 502.* *(Reg. No. 111.)*

HAIRY CATERPILLARS.

443. This very common moth was found feeding on tea at one or two localities. The caterpillars were collected and reared for me by Mr. J. A. Thomson at Ligri Pukri, Sibsagar. It can hardly be said to be a pest, but no member of this family should be looked upon as harmless.

Family ARCTIIDÆ.

444. This family of nocturnal moths are like the last characterised by having fairly large hairy caterpillars. It is probable that some half a dozen or more species are occasionally found on the tea plant, but none of them have as yet assumed a very definite position as tea pests.

50 maunds Collected Daily. *Conf. with para. 350.*

Mr. Cotes refers (*Insects and Mites, etc., p. 22*) to a caterpillar of what, he presumed, might be a species of this family. The samples were sent to the Museum in April 1891 by Messrs. Andrew, Yule & Co. from a garden in Jorhat. "The manager of one of the gardens wrote that he had been getting twenty-five 2-md. bags of these caterpillars picked off the bushes daily, and, that in spite of all efforts, they seemed rather to increase in numbers. They stripped the leaves and the bark of the bushes to such an extent as in some cases to kill the plants. The manager added that, during the ten years he had been in the district, he had never seen such a visitation and that his coolie sirdars, some of whom had been over 20 years on the garden, could not remember the like." (*Conf. with para. 487*).

44. (a) Arctia ricini, *Fabr.*

References.—*Hampson, Fauna Br. Ind. (Moths), Vol. II, 17: Ind. Mus. Notes, III. (6), 14.*

445. In the Journal, Agri.-Horticultural Society of India (*Vol. XI., Proc. 26th March 1897*), p. 603, it is stated that Messrs. Andrew, Yule & Co., submitted to the Society samples of an insect sent by the

manager of the Singtom Tea Estate, Darjeeling. The manager wrote: "The Caterpillars are in millions here and are quite stripping the bushes of their old leaves." **HAIRY CATERPILLARS.**

45. (c) Creatonotus lactineus, *Cram.*

References.—*Hampson, Fauna British India (Moths), Vol. II., 27; Ind. Mus. Notes, I., 55; II., 158; Vol., III., (pt. 5), 57-58.*

(Reg. No. 112, tube No. 53.)

446. History.—This well-known defoliator has never before been recorded as found on tea. The caterpillar is easily recognized by its dense coat of long black glossy hairs. It seems probable that it may have been the insect alluded to above as having suddenly assumed such proportions in Jorhat. I found it on two or three occasions, and Mr. J. A. Thomson, of Ligri Pukri, was good enough to rear for me a few of the caterpillars, so that I have been enabled to obtain the perfect insect, and can, therefore, speak with certainty as to its being a tea pest. The moth is pure white with a scarlet band along the margin of the upper pair of wings, and has four black spots on the lower wings. The body is yellow stripped transversely with black. **Black Hairy Caterpillar.**

447. Depredations.—In the *Indian Museum Notes* (*Vol. I., p. 55*) it is spoken of as a pest of agricultural crops in the Central Provinces, where the caterpillar is known as *bhalu pok.* Mr. Middleton (*Mus. Notes, Vol. III.*) speaks of it as a pest of a very serious nature in Baroda where it is known as *Katra.* "The caterpillars appear about a fortnight after the first fall of rain when the crops are beginning to grow. It attacks cotton, sesamum, pulses of all kinds, brinjal and other plants. It often makes a clean sweep of a field beginning on one side and finishing on the other. If the weather is dry, its ravages may continue for three weeks or more, but, if heavy rain falls, it rapidly disappears." **Pests on Agricultural Crops.**

Mr. Nietner tells us that it had occasionally been found to attack coffee. **A Coffee Pest.**

448. Remedy.—After the above abstract of information it is hardly necessary for me to remark that every effort should be made to prevent this caterpillar from getting a footing in tea plantations.

46. (c) Creatonotus emittens, *Wlk.*

449. This insect was also found by me on the tea plant in Assam, but fortunately only very rarely.

Lepidoptera (Arctiidæ).

AGROTIS YPSILON.

LIX.—Nocturnal Moths with Mostly Naked Caterpillars,

Family NOCTUIDÆ.

450. This very large family of moths are, with few exceptions, nocturnal. The larvæ are naked; in the great majority of species they pupate in the ground and only exceptionally form a cocoon.

CUT WORM.

Conf. with para. 46 (?).

47. (b) Agrotis ypsilon, *Rott.* (Noctua suffusa, *Fabr.*).

THE CUT WORM OR BLACK GRUB.

References.—*Hampson, Fauna British India (Moths), Vol. II., 182; Green, Insect Pests of the Tea Plant, 57-62; Bamber, Chem. and Agri. of Tea, 244; Ind. Mus. Notes, Vol. I., 95, 103, 108, 206; Vol. II., 6, 161; III., 16, 98; Cotes, Insects and Mites, etc., 24-25.*

Enemy of Seedlings.

451. HISTORY.—Mr. Green says, "This caterpillar and its allies are well-known agricultural pests all over the world; in Ceylon they are most destructive in tea nurseries and to young plants growing from seed-at-stake, in the latter case the pest is even more annoying, as, owing to the extended area, little can be done to check it." Though many planters spoke to me of the destruction of seedlings in such a way as to lead me to suspect this worm as the enemy, in every case when personally investigated, the insect proved to be the cricket, and not cut worm. I do not doubt but that the cut worm does attack tea, but like Mr. Cotes I have to record that I have no positive information on that point.

Eats Lower Portion of Stem.

452. DEPREDATION.—Mr. Green says, "The caterpillars hide themselves in the ground during day time, and are particularly fond of the loose earth of nursery beds; at night they come to feed, and then the work of destruction commences. The animal wastes very much more than it consumes, for it will eat only the succulent part of the stem where it joins on to the root. While the caterpillar is young, it may perhaps be content with sacrificing one plant each night, but as it grows larger it increases the number until the full-grown larva may very possibly shear off ten or twelve plants at each meal: in the morning the severed plants will be found lying where they fell, looking just as if they had been cut off with a knife, and the perpetrator of the outrage will have taken refuge again underground." "When ready to undergo its transformation, it forms a rough earthen cocoon underground, within which it changes to a bright red chrysalis."

Collect the Grubs.

453. REMEDY.—"The only remedy for this pest is, collecting the grubs each morning and destroying them before they can do any more

mischief. With a little practice, the burrow of the caterpillar can generally be found near one of the decapitated plants, sometimes it is indicated by few green leaves partially drawn into the opening. The grub will be found about an inch below the surface, generally coiled up." "Smooth conical holes sunk in the beds have sometimes been found successful as traps; the caterpillars wandering about at night, fall into these pits and are unable to climb out: they should be formed with a smoothly pointed stake, pressed into the moist earth and rotated until the sides of the holes are smooth and firm." (*Green.*)

CUT WORM or BLACK GRUB.

Caught in Small Pits.

48. (a) Ophiusa melicerte, *Drury.*

References.—*Hampson, Fauna British India* (*Moths*), *Vol. II.*, *494; Achæa melicerte, Ind. Mus. Notes, Vol. III.*, *112; Cotes, Insects and Mites, etc.*, *p. 26.*

454. History.—Mr. Cotes informs us that the caterpillar of this moth was reported from Dehra Dun to have done considerable damage to tea in 1892. It was not found by me in Assam.

49. (c) Ophideres fullonica, *Linn.*

References.—*Hampson, Fauna British India* (*Moths*), *Vol. II.*, *560.*

455. The caterpillars of this very common moth were collected, on one or two occasions, on tea, and reared until the perfect insect was produced. It can hardly as yet be regarded as a tea pest.

Family GEOMETRIDÆ.

456. The moths that belong to this family may be designated the Loopers, because of the peculiarity of the caterpillars, when walking, throwing up the body in a loop. Three pairs of the medial prolegs are abortive, and the fourth pair carried near to the anal prolegs. In consequence, during movement the anal extremity with its four claspers is brought close up to the thoracic. The head is then raised and extended to the full length of the body, when the thoracic feet lay hold and the anal extremity is again brought forward. The body is thus looped up with each act of progression.

THE LOOPERS.

457. Under the account of the *Family* Lymantriidæ (*B*, page 231) mention has been made of a caterpillar that had been sent from the Nowgong District. Mr. Cotes mentions a looper having in the same year been obtained from that district. On page 23 of *Insects and Mites, etc.*, he gives a figure of the looper, life size. During my

Lepidoptera (Geometriidæ).

EUSCHEMA MILITARIS.

explorations I came across at least two, if not three or four, geometrid caterpillar on tea. The following may be specially mentioned :—

A Green Looper.

458. (*A*) At Ligri Pukri, on the 17th April I found a caterpillar about 2½ inches long (or fully an inch longer than the insect figured by **Mr. Cotes**). It was of a pale green colour and had the head, as also anal somite, yellow, while along the sides of the other somites a narrow bluish band extended with above this four pale yellow spots. It formed a yellow chrysalis on the 20th April which had a row of large green spots with blue centres. This was suspended by the pointed extremity from a leaf. Unfortunately the moth did not emerge, possibly owing to the caterpillar not having been sufficiently well cared for in captivity. This same caterpillar I came across on several occasions. Though not abundant, I had a good many brought me, and I had the opportunity of seeing that they might be a cause of considerable anxiety should they unexpectedly increase very greatly in number. (*Reg. No. 40, tube No. 214.*)

Grey Looper 3–4 inches long.

459. (*B*) At Nigiriting I discovered another geometrid feeding on the tea. This held on to the twig by its anal claspers and eat the leaf from the margin inwards, the head eating down and along the face of a section until a considerable piece was cut out. The position of the anal extremity was then slightly changed so as to give a greater extension to the head. In this way the leaf seems to be as a rule, cut across the middle, the upper half being wasted and the lower eaten down to the petiole. The caterpillar to which I allude was fully 3½ inches long, of a dirty dull greenish grey colour, perfectly smooth and hairless, but for its length a very slender worm. On each of the seven abdominal somites (between the two sets of legs) there were circular markings, and from the top of the second to the bottom of the first somite, a sickle-shaped marking occurs.

This is very probably the insect figured by **Mr. Cotes**, but in that case the caterpillars must have been sent to him in a very immature condition. (*Reg. No. 62, tube No. 96.*)

50. (c) Euschema militaris, *Linn.*

References.—*Hampson, Fauna British India (Moths), Vol. III. 468.* (*Reg. No. 113.*)

460. The caterpillar of this extremely abundant moth was picked off the tea bushes by **Mr. J. A. Thomson**, and reared until the perfect insect had been obtained. It is fortunate that so far this moth

has shown no very decided liking for tea, since it is perhaps one of the most plentiful in Assam. Unlike majority of the family to which it belongs, it is to be seen on wing during day time and in shape of wing and flight is more like a butterfly than a moth. It is a large insect, the prevailing colour being golden yellow with deep purple spots, especially near the outer half of the wings. **LEAF-ROLLERS.**

LX.—Leaf-Rollers and Leaf-Tiers. **LEAF-TIERS.**

Families TORTRICIDÆ & TINEIDÆ.

461. The very large assemblage of minute moths that have to be assigned to these, and perhaps one or two other families, may, for the purpose of this report, be dealt with conjointly. This is the more necessary since comparatively few of the species of Indian Tortrices, Tineas and Plumes, have as yet been identified and named. Collectively they may be designated the Leaf-rollers and Leaf-tiers.

Though minute insects, they are very destructive, and some three or four species are plentiful tea pests.

51. (c) Gracilaria theivora, *Wlsm.*

THE TEA-LEAF ROLLER. **LEAF-ROLLER.** ***Conf. with para. 40 (8).***

References.– *Green, Pests of the Tea Plant, 62-66* ; *Ind. Mus. Notes, Vol. II. 49, 164 ; Cotes, Insects and Mites, etc., 27.*
(Reg. No. 30, tube No. 283.)

462. HISTORY.—**Mr. Green** was the first to discover this pest, and in his most useful little book, ***Pests of Tea Plant,*** rightly referred it to the genus **Gracilaria. Lord Walsingham** shortly after published a scientific description of the species in the ***Indian Museum Notes*** (*Vol. II., 49*). **Mr. Cotes** in his ***Insects and Mites, etc., of the Tea Plant,*** says, that it had "not been recorded from India."

It was collected by me throughout Assam, no garden, so far as I recollect, being free from it, though in some it is rare, and in others a serious pest. Specimens from my collections were submitted to **Mr. Green,** who has been good enough to confirm my determination, that the Assam insect is absolutely the same as that recorded in Ceylon. This is very possibly the leaf-roller referred to by **Mr. Bamber** as a Tortricid. **Very Common in Assam.**

463. DESCRIPTION.—The egg is deposited near the midrib and on the under surface of the leaf. On hatching, the minute caterpillar is at first a leaf-miner. It eats along, in a somewhat tortuous course, **Early Stage a Leaf-miner.**

Lepidoptera (Tortricidæ).

GRACILARIA THEIVORA.

Its Later Stage a Leaf-roller.

towards the margin. It then escapes and becomes a leaf-roller. It causes the margin of the leaf, for about half to an inch in length and perhaps less than one-eighth of an inch in breadth, to turn over itself. Within that enclosure it commences to eat the epidermis of the enclosed portion. Shortly after, however, it migrates to a fresh leaf and now commences its more vigorous action. The overturned margin dies, and gives to the leaf a withered, discoloured and torn appearance. Few gardens exist in which leaves, that would answer to my description, are unusual, though their wretched condition is generally attributed to hail or rough handling, on the part of coolies.

It requires very little skill to recognize the winding slightly discoloured passage within the texture of the leaf and the overturned margin described above (Fig. 9 (*a*)) ; all such leaves should be instantly removed in order to check further depredations.

464. In the rough sketch of a leaf taken possession of by this pest, I have Fig. 9 shown both the leaf-mining stage (*a*) and the leaf-rolling (*b*) on the same leaf. This may be taken as rarely happening. The insect in fact, during its larval existence, repeatedly changes its house, and thus destroys a large number of leaves. The caterpillar (*c*) is shown greatly enlarged. It is a minute yellow-white creature which, when full grown, is little more than half an inch in length. It will be observed to possess only three pairs of prolegs in the middle of its body.

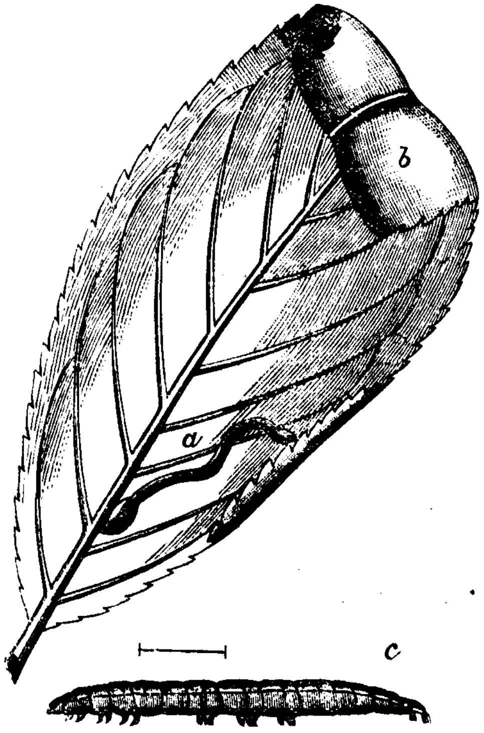

FIG. 9. THE TEA LEAF ROLLER.

465. Depredations.—The following passages from my diary may be here given as completing the description of the pest and narrating its method of procedure.

THE TEA-LEAF ROLLER.

At Ligri Pukri, on April 17th I endeavoured to investigate some of the features in the life history of a curiously destructive caterpillar A white, smooth, transparent, almost hairless creature that rolls the tip of the leaf over the under-surface, and coils it round and round, very frequently obliquely across the left side of the midrib, at other times the right side. One or both ends are carefully sewn up as the leaf is rolled round, and when the conch-shell-like structure, thus formed, has been completely wound up and firmly bound together at both ends, the caterpillar proceeds to eat the leaf from the tip downwards. As it progresses, the excretory matter is carefully packed on one side, and partitioned off by a fold of the margin of the leaf brought down for that purpose. When the contained portions of the leaf have been devoured, the operation of winding up the leaf still further is renewed. Coil after coil is made, but usually not more than half the leaf is eaten. The insect then migrates and commences once more to roll a leaf around itself.

Method of Coiling the Leaf.

It never, however, severs its house in any way from the rest of the leaf, but, on the contrary, the shattered leaf again uncoils when the caterpillar leaves it. In fact to allow of its free egress, it methodically forms a door. It seems, moreover, to always leave its feeding house when the time arrives for its changing into the condition of a chrysalis.

466. During my study of this caterpillar I uncoiled a leaf house and placed it on my table. The caterpillar at once proceeded to coil the leaf round itself once more, and in 20 minutes it had completely accomplished that object. Raising itself to its full height, it applied its mouth to a distant part of the leaf, the head was then swept rapidly to the opposite margin and a thread attached there. Backwards and forwards the head moved for 3 or 4 seconds in the same direction, then it was carried down to the bottom across the strands, and up through them again carrying as it were cross threads that tightened the former ones and thus brought the fold of the leaf over itself. While engaged in this cross binding operation, the caterpillar held on by its anal prolegs and made the whole of the rest of its body swing backwards and forwards with great rapidity. In another leaf

Takes Twenty Minutes to Construct its House.

Lepidoptera (Tortricidæ).

GRACILARIA THEIVORA.

unfolded, two caterpillars were found, and it was interesting to watch how they acted in concert the heads flying backwards and forwards in the exact same direction for a time, then changing to the opposite action simultaneously.

Punctures or Bites the Surface of Leaf.

467. In causing the leaf to coil this insect seems to nip the midrib, and at the points of reversion too, it often cuts it nearly through. The surface of the leaf within the coiled-up portion is also seen to be punctured more or less all over. These punctures soon turn brownish, and to the naked eye resembled minute scales. These were at first taken for eggs of some kind, but under the microscope were found to be actual puncturings, hence it would appear the caterpillar sucks the sap of the leaf and eats a layer of the cellular tissue as well. Within the coiled-up portion there is always a little watery fluid. This seems to decompose the leaf since the coiled-up portions are often observed to be quite brown and membraneous in addition to the fact that the soft pulpy under-surface has been completely eaten away.

The Leaf Subsequently Uncoils and Becomes Attacked by Fungi.

468. It was also noted that the insect destroys its silken cords before emerging from its conch-shell house and in consequence the leaves, as already remarked, uncoil to a certain extent. They then constitute a large percentage of the leaves that are seen to have rotten and fungoid-attacked tips. In this respect, however, the final action of the leaf-roller is not so objectionable as the sandwich caterpillar described below, since it destroys, as a rule, only one leaf at a time and but the top half of that, whereas the sandwich insect unites together a large number of leaves, destroys the middle and lower portions of them and leaves behind it a putrid and decomposing mass, the nursery-bed doubtless of many other pests.

Appearance of Caterpillar.

469. On another occasion I endeavoured to settle one or two doubtful points regarding this clever little house builder. I may, therefore, record my observations. Its body is white, semi-transparent, with only a few long scattered hairs to each somite, and no spots or markings as in the sandwich caterpillar. On looking through it, however, it seems as if its whole texture were divided down the back into lateral bands of muscular tissue connected together by a very thin integument. Inside several contorted cream-white alimentary tubes are visible which move backwards and forwards during digestion. It may be said to have three pairs of anterior feet and only 3 + 1 pairs of posterior (prolegs).

These doubtless are observations of a very general nature, but

they may help the planter to recognise this insect, and that is my chief object. Thus structurally it may be said to be very different from the sandwich caterpillar; it is a little smaller in size and white, instead of dark dirty white, with reddish brown spots (ultimately stripes), as in the other worm. THE TEA-LEAF ROLLER.

470. On the conch-shell houses being plucked, the caterpillars come out since the leaves soon thereafter begin to wither. If given fresh leaves they refuse to form new houses in captivity so that a difficulty exists in rearing them. To overcome this Mr. J. A. Thomson undertook to carry out a series of experiments started on April 17th. Six muslin bags, each 3 to 6 inches in size, had two of those caterpillars placed within, and then inverted over and tied round a healthy twig. The object was to get them to attack the enclosed leaves, eat and form cocoons, and in time come out as perfect insects. To make certain of obtaining this object, six twigs were also selected, each found to contain a rolled-up leaf. These were with the utmost care tied within muslin bags and were to have been left undisturbed in order to allow the insects to be formed. But both experiments failed completely, since next day the caterpillars in each case, finding themselves prisoners, cut holes through the muslin bags and made off. To rear the insect, therefore, it is necessary to enclose a seedling within a fine zinc gauze cage. Experiment to Rear the Caterpillar.

471. The cocoons may easily be discovered, however, and the perfect insect obtained from them. When mature, the caterpillar spins a small silken cocoon about one quarter of an inch long and little more than one-sixteenth in breadth. This will be found within depressions of the leaf or under the lee of the midrib. It opens by a circular mouth, to allow of the escape of the perfect insect.

472. I found this moth specially bad in the Sibsagar District. In one garden, during April and May, every bush might have three or four leaf-rollers upon it. It does not go for the old and comparatively useless leaves of the plant, but for the second, third and fourth leaves of the young shoots, so that it directly interferes with the yield, and if accidentally plucked and made into tea, to any appreciable extent, would certainly not improve the flavour. It is, therefore, a dangerous pest and should be kept well under hand. But let me add, I found few planters prepared even to look at this, as more than a curiosity. "A pest no doubt but one that had always Common in Sibsagar.

Lepidoptera (Tortricidæ).

CAPUA MENCIANA.

existed." The injury it effects is not so self evident as in the far less injurious pest, **Andraca bipunctata.** Planters have no hesitation in putting on a large staff to collect "caterpillar," but the leaf-roller does not defoliate the bushes and is thus of no great moment? These are the views I found held by many planters and yet I feel certain that, if careful estimates of the occasional loss from "caterpillar" and continuous loss from the "leaf-roller" were to be made, it would be found the latter was infinitely the more serious pest of the two.

Pluck and Destroy the Affected Leaves.

473. Remedy.—There is but one cure put on all hands and pick off the rolled-up leaves, but more especially the tunnelled leaves, with reflexed margins. If these contain the larvæ, every leaf so plucked means the saving of perhaps a dozen leaves that would be subsequently rolled up and destroyed.

KANGRA LEAF-ROLLER.

52. (c) Kangra Tea-Leaf-Roller.

474. I was unable to investigate this insect during my rapid exploration of the gardens of Kangra, but I saw enough to satisfy me that it was not **Gracilaria theivora,** though it might possibly be an allied species. It at least belongs to the same Family and differs mainly in the fact that, as the leaf is rolled up, the portion so utilized is severed from the rest of the leaf, and so completely sewn down that it forms a hard, somewhat triangular structure about half an inch in length.

This insect deserves to be carefully watched and its life history worked out.

53. (b) Capua menciana, *Wlk.*

THE TEA TORTRIX.

The Tea Tortrix.

References.—*Green, Pests of the Tea Plant, 89-93; Cotes, Insects and Mites, etc., 28.*

475 History.—So far as I have been able to discover, this tea pest does not occur in Assam. **Mr. Green** says, "The Tortrix caterpillar causes as much injury by twisting up the leaves and spinning them together with a fine web as it does by the actual amount of food it consumes. I am told that the whole flush over large fields has been ruined in this manner.

54. (c) Bud-involving Tortrix.

(Reg. No. 9, tube No. 161.)

476. History.—In Assam it is by no means uncommon to find the

first leaf, and perhaps the second also, firmly woven to the bud by a destructive little worm that eats the stem of the bud and then changes its abode. If the leaves are removed, a small hole into the bud stem will generally be seen, so that the pest might be called a boring caterpillar. I found this here and there in Dibrugarh, Sibsagar and Nowgong, but so prevalent in Patalipam, and in the gardens of the north bank generally, as to amount to a serious pest. BUD-INVOLVING TORTRIX.

Unfortunately I was unable to collect sufficient material to allow of anything being written regarding this very destructive insect. I have only offered these remarks regarding it, in order to draw attention to its existence and to suggest the desirability of some attention being given to this very obscure enemy of tea cultivation.

55. (c) THE INDIAN LEAF-TIER OR SANDWICH CATERPILLAR. SANDWICH CATERPILLAR.

References.—*Ind. Mus. Notes, Vol. IV., 61.*

(*Reg. No. 29, tubes Nos. 104, 170, 340.*)

477. HISTORY.—Very closely allied to the two insects mentioned above, comes the one to which I have given the fanciful name of Sandwich Caterpillar. A sample was sent by me to Mr. Green for favour of opinion. His reply was to the effect that "the insect was quite new to him, and appeared to be one of the larger Tineid moths Lord Walsingham, he added, is the only person, very possibly, who could identify it." This insect I found very frequent in Assam. I have had the pleasure to compare, along with Mr. Barlow, the caterpillars recently sent to the Indian Museum by Messrs. Finlay, Muir & Co. from their Mukhamcherra Tea Estate in Sylhet. There seems a strong probability that the Sylhet insect is identical with this Assam insect, but one would require to see more than the caterpillars in order to be certain on this point, since many of the caterpillars of this family are very similar. It would be difficult indeed to separate the caterpillars of No. 54, from 55, and the Sylhet insect may be a third, but it certainly belongs to the same group of insects and is very possibly a dangerous pest. Assam and Cachar.

478. DESCRIPTION.—This extremely active little caterpillar is doubtless the most dangerous tea pest of this family of moths. The following passages from my diary may be here given as descriptive of the species :—

On the 16th April I gave attention to a small caterpillar, that does much harm at Ligri Pukri and a few other gardens in the

Lepidoptera (Tineidæ).

SANDWICH CATERPILLAR.

Nazira neighbourhood. This had been previously observed by me, but not to any very appreciable extent. Since it is very destructive, its chief characteristics may be here detailed. It brings down a few leaves flat on the top of each other and ties them in that position by silken threads. Two, three or more form its house, but it adds a fresh leaf with dew on it day after day until it has fastened together a fairly conspicuous mass, the bottom leaves of which become rotten. Bushes with this pest upon them consequently appear very untidy. When opened up the older leaves of the sandwich masses are seen to be eaten about the middle and lower half, and according to age manifest brown rotten portions and numerous perforations. On tearing the topmost leaf off a little water will generally be found within, together with a large quantity of excretory matter and fragments of leaves. The agent of this destruction will readily be recognized as a small, very active little caterpillar, one or two of which will often be found within each of these bundles of leaves sewn together.

Method of Forming the Sandwich Masses of Leaves.

Description of the Caterpillar. *Conf. with pp. 252–254.*

479. The caterpillars are generally $\frac{1}{2}$ to 1 inch in length and a $\frac{1}{10}$ or thereby in thickness. They are long, narrow, quick moving creatures, of a dirty brownish-green above, and yellow or orange below, smooth, shining and hairless, except one or two long white hairs, which spring from the bottom one of an inverted triangle of three spots on the sides of each segment of the body. In older insects hairs may also be seen springing from the top spots as well, so that in that case three spreading hairs occur on the sides of the somites which otherwise are smooth and naked. The terminal segment and the head are dark brown, and the last two anal segments have retractile portions, which are possibly used to enable the worm to wriggle and jump when disturbed. An important difference between this caterpillar and the leaf-roller already described exists in the fact that it has four pairs of prolegs in the middle of the body instead of three pairs.

It Has Four Pairs of Prolegs in Middle of Body.

480. Large consolidated slabs of decomposing leaves drawn together from all the neighbouring twigs are not only unsightly and destructive to a distinct proportion of the flushing power of the bush, but positively dangerous. I cannot say that thread blight is a fungus that has been demonstrated by me as being in direct association with the sandwich caterpillar, but it is within the bounds of possibi-

SANDWICH CATERPILLAR.

A Nidus for Other Pests.

lity that the decomposing structure and the contained manure left by that insect might become the nidus in which thread blight and other pests originated. Many fungi are purely saprophytic in the first half of their lives, and parasitic during the second. That is to say, they live for a time on decomposing vegetable matter before they are able to attack living plants. In the sandwich masses of leaves and excretory matter, a fertile bed for the propagation of many such germs would no doubt exist. Apart, therefore, from all other considerations they should be *instantly* removed. Fortunately this curious little pest is one easily seen, and the nimble hands and the quick eyes of the children should be at once utilized in removing and bringing the patches with their contained caterpillars to the factory to be there destroyed. There is no other treatment simpler, nor more likely to be successful, than systematic and persistent plucking.

Older Caterpillars.

481. On the 19th April I collected some more sandwich caterpillars, and re-examined them. On this occasion they were found to be larger and more green-coloured than the insect already described, but I satisfied myself that they are same species. Forelegs 3 jointed. From the bottom spot (or stoma) of each somite a sensitive hair arises. Near the stoma, a delicate thread may be seen, within the transparent body; it divides into two main arms, one goes to left and connects with next somite in front, the other bifurcates to the upper pair of spots of the somite. These spots have each a sensitive external hair.

In spinning its nest within the sandwich mass of leaves, the insect turns over the margin of one or two leaves, and takes about half an hour to accomplish this task.

Chrysalis.

The chrysalis is a naked, black-brown little structure with a polished shining surface. It has the power of jumping when disturbed.

The Caterpillars Become Reddish.

482. At Atkhel, Noakachari, Moaband and Jorhat I found many leaves sewn together and the caterpillars within them mostly larger and more reddish coloured with two lateral dark stripes, as compared with the worms examined in other gardens. This is doubtless due to age, the caterpillar lives apparently for a fairly long period, becomes larger, more hairy and darker-coloured. But I may here add that at the Dibrugarh gardens, more especially Panitola and Jaipur, I searched for, and failed, to find this pest. But at Patalipam I met with it once more and came across an instance in which thread blight seemed

SANDWICH CATERPILLAR.

undoubtedly to originate from the decomposing leaves produced by the caterpillar. The chrysalides are small, black, polished bodies fastened within the sandwich masses of leaves. From these escape small dirty white moths. They are too small to be readily seen on the wing by coolies employed to collect moths.

Collect and Destroy the Sandwich Masses.

483. DEPREDATIONS AND REMEDY.—After what has been said, in the above passages from my diary of observations made while on tour through Assam, it is scarcely necessary to repeat that the injury this insect is capable of performing is very great indeed. Every effort should, therefore, be at once made to collect and destroy the sandwich masses. When found fresh and green, these will contain the active caterpillars or, when withered, they most probably may each have one or more chrysalides. In both cases, therefore, it is desirable to remove and destroy them, even should it be found that there is little ground for the suggestion that these decomposing masses of leaves become the breeding places for other pests and blights.

FORMING TINEID.

56. (c) THE HOUSE-FORMING TINEID.

(*Reg. No. 44, tubes Nos. 56 and 223.*)

484. HISTORY.—This very curious insect was not seen by me personally, and the specimens recorded above were presented to me by Mr. J. Lees, Manager of Borsillah. It may, perhaps, best convey an idea of this pest if I give here the passage from my diary which records my conversation with Mr. Lees, on this subject.

485. DESCRIPTION.—In the evening of the 21st April I had some conversation with Mr. Lees, the manager of Borsillah. He showed me a few old specimens of an insect that some time ago did very considerable injury. It was a small grey moth not unlike the sandwich insect, only considerably smaller and of a dirty milky-white colour. The caterpillar, I was told, ate the bark of the younger twigs as also the leaves. It appeared first about December, and as Mr. Lees had not seen the perfect insect, he took some caterpillars and fed them under a glass. This must have been somewhere in March or the beginning of April. These formed small black pupal cases, and shortly after came out grey moths. In tube No. 223 are a few old empty pupal cases, and in tube No. 56 a few rather broken moths — these were given me as being the insect in question. The stems of the tea plant eaten by the caterpillar were also preserved by

Mr. Lees and presented to me. The series of specimens were thus sufficient to enable me to decide that it was a Tineid moth.

HOUSE-FORMING TINEID.

486. The caterpillar was described as having been a very active little worm about an inch long, main colour brown with two yellow or orange lateral bands and with a few straight hairs scattered over the body. It lived in a small house formed by fastening a fragment of a leaf on to the bifurcation of a twig. When out eating bark or leaf, it was said to drop to the ground on the slightest disturbance, suspending itself on a silken thread, or to make off to the shelter of its house. At other times it lived in the axils of the leaves, but only one worm is found in one place. Sometimes they may be observed to nip off a portion of a leaf and to make off with that to their house. The leaf that constitutes the house withers, and thus becomes scarcely distinguishable from other dead leaves.

Fragment of Leaf Fastened at Bifurcation of Twigs.

487. Depredations.—This harmless-looking insect does terrible damage, sometimes killing outright the bushes. It is curious, however, that so far this insect seems to be very local. Mr. Lees assures me that it was the insect sent to the Indian Museum from Jorhat, and which Mr. Cotes alludes to at page 22 of *Insects and Mites, etc.* Mr. Cotes was of opinion that the insect in question was a member of the Bombyces, whereas Mr. Lees' insect, given to me, does not form a cocoon of any kind. There would thus seem to be an important confliction in the identification of the Jorhat insect. (*Conf. with para. 444.*)

Kills the Bushes.

488. Mr. Lees' specimens bear a very strong resemblance to my so-called sandwich caterpillar. Since I wrote my first notes on that insect, I have found that it lives in the larval stage for a very long period, assumes intervals of repose, and comes forth again still in the larval state. In these various changes it grows larger in size, and apparently darker in colour, than I first suspected. It becomes in fact almost black and has two lateral yellow or orange-coloured stripes. But I have never observed the sandwich caterpillar to either attack the bark or to form a house in the manner mentioned by Mr. Lees, so that it seems the safer conclusion that they are distinct species. When shown the sandwich caterpillar Mr. Lees at first took them to be the same, and then thought they were too small and had other points of difference.

Sandwich Caterpillar.

489. Remedy.—It is a most significant and fortunate circumstance that the house-forming Tineid here indicated should have suddenly

The House-forming Tineid.

HOUSE-FORMING TINEID.

Persistent Picking.

Firing the Bushes.

appeared and as suddenly disappeared. Had the pest continued, I can well believe that it would be extremely difficult to deal with. There clearly can be no remedy but persistent picking. Where the life of the bushes are threatened, and the worms too numerous to be picked, then firing might be resorted to, provided the pest be confined to a fixed and limited area. Insecticides seem to me hopeless with an active worm of this nature that would either leave the bush or seek the protection of its house on the slightest disturbance.

LEAF-MINING FLY.

CHAPTER XII.*

DIPTERA.

LXI.—The Flies, Gnats, Daddy Longlegs, Hessian Fly, Gad Fly, Horse and Cattle Flies, etc.

490. The maggots or larvæ of a large number of the Two Winged Flies (DIPTERA) are dangerous pests. They are, with few exceptions, footless, and in many instances hardly possess what could be called a head. There is only one tea parasite, so far as is known, that belongs to this Order of insects, *viz.*, **Oscinis theæ.** There are, however, a large number of friendly Dipterous flies parasitic upon the larvæ and chrysalides of many of the moths described above.

57. (c) Oscinis theæ, *Bigot.*

THE TEA LEAF-MINING FLY.

LEAF-MINING FLY. *Conf. with para. 46 (9), 514.*

References.—*Green, Insect Pests of the Tea Plant, 55-57 ; Bamber, Chem. and Agri. Tea, pp. 245, 255 ; Ind. Mus. Notes, Vol. I., p. 204 ; II., 165 ; III., 138 ; Cotes, Insects and Mites, etc., 28.* (*Reg. No. 9, Tube No. 161.*)

491. HISTORY.—I have given the specific name **theæ** on the authority of the *Indian Museum Notes, Vol. I., (pl. 4), 204.* Mr. Green was the first to draw attention to this insect as a tea pest. Mr. Bamber alludes to it (*Chemistry and Agriculture of Tea, published in 1893*) in two places, once in its true position as a species of DIPTERA, and again at the end of his account of Scale Insects. In both positions he calls it **Agromyla,** obviously a misprint for **Agromyza.** It seems probable that the one leaf-mining insect, which Mr. Bamber may have had in his mind, was the early stage of **Gracilaria theivora,** the other, the insect which it is desired to exhibit in this place. But Mr. Cotes (*Insects and Mites, etc., published, 1895*) states that this insect "has not yet been recorded from India." It would thus appear that Mr. Bamber's remarks were not regarded as establishing the species as an Indian tea pest. It was found by me in every garden in Assam, and samples sent to Mr. Green, who has been good enough to examine them and to report that they are identical with the Ceylon insect. There is, therefore, now no longer any room for doubt as to the existence of this tea pest in Assam.

Common in Assam.

Hymenoptera.

OCINIS THEÆ.

492. Description.—The rough sketch opposite gives the appearance of a leaf, burrowed by this insect. After wandering about to a considerable extent and devouring the tissue, below the upper epidermis, the larva moves towards the margin and there pupates. The letter (*a*) Fig. 10, indicates the pupal case. In Ceylon the larvæ seem to form sinuous tunnels instead of burrowing and eating over a more or less compact space—the habit of the Indian insect.

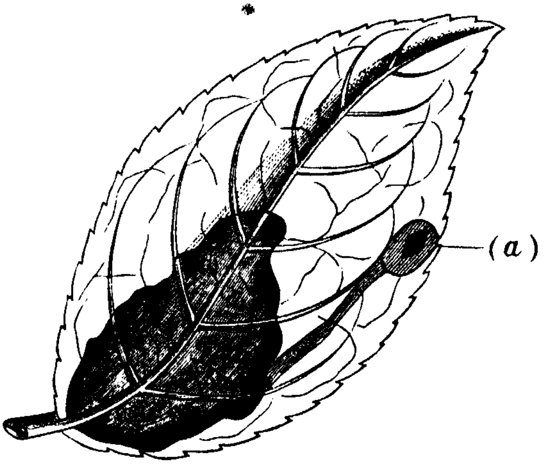

Fig. 10. The Tea Leaf Mining Fly.

Found on Last Year's Leaves.

493. Depredations.—Fortunately this interesting little fly seems to prefer last year's leaves, and not more than one affected leaf here and there can be said to be met with, so that at present it has to be viewed as a curiosity more than a pest. At the same time I have found some gardens sufficiently attacked to suggest the undesirability of this fly being allowed to increase. **Green** tells us that the larvæ lie from first to last in the single leaf upon which the egg was first deposited. "The action," he remarks, "of the little miner, while at work, can be distinctly seen through the thin cuticle of the leaf It moves its head —which contains a sharp cutting instrument—in regular sweeps, like a mower with his scythe. At each sweep a portion of the cuticle is separated from the leaf and (presumably) a portion of the leaf is taken into the animal's body. It is a very rapid worker: a specimen under examination cleared a space more than twice its own size within half an hour's time."

It may be here added, however, that several allied insects, such as the Hessian Fly on wheat, the Frit Fly on oats, the Turnip leaf-miner, the Rice Fly and many such agricultural pests, show that

mining flies cannot be despised. There can be no doubt that every leaf invaded, is destroyed to the plant, and the study of pests is beset with sudden and unexpected expansions, so that it would be unsafe to say that this minute parasite is incapable of ever becoming a source of anxiety to the tea planter. **RED-BLACK ANT.** **Other Mining Pests.**

HYMENOPTERA.

LXII.—The Saw-flies, Gall-flies, Ichneumon-flies, Bees, Wasps and Ants.

494. This order of insects embraces a good few forms that are destructive to plants such as the Saw-flies and Gall-flies, but many others that are parasitic on plant pests, such as the Ichneumon-flies. It is somewhat curious that no species of Saw-fly nor Gall-fly has, so far, been recorded as met with on the tea.

The members of this Order are all characterised by the possession of mandibles; wings when present in two pairs which, during flight, are often linked together so as to act as one pair; and by the first segment of the abdomen being separated from the remaining segments and united to the thorax, the attachment of the remainder of the abdomen being by a flexible joint.

Two species of ants are commonly found on the tea plant. Some planters regard these as friendly. They are as follows :—

58. (c) Cremastogaster contenta, *Mayr.*

THE RED AND BLACK ANT OF THE TEA BUSHES. **RED-BLACK ANT.**

495. HISTORY.—This insect, while not hitherto apparently recorded as a pest of tea cultivation, is closely allied to **Cremastogaster Dohrni,** *Mayr.*, which in Ceylon has been found to injure Cinchona, Coffee and Tea. It forms small, black-looking, mud enclosures, around the twigs, mostly near the bifurcations of the shoots. These may at first be only an inch in length, and contain perhaps not more than a dozen ants. In course of time, however, they gradually increase in size until they become from a foot to a foot and half in diameter, and then contain many thousand ants. The hive is constructed of a black papier-mache looking material, in which no doubt there is a large proportion of mud. It is formed more or less in layers, so it would appear when viewed from the outside, but, on being cut open, it is seen to be composed of a vast number of **Hives on Tea Bushes.**

Hymenoptera.

CREMASTOGASTER CONTENTA.

galleries of cells in every direction. There is no outer protecting membrane, and it is of one material throughout.

496. In one garden, in the Sibsagar District, the superintendent told me he believed most thoroughly in this ant as protecting the estate from insect pests; accordingly, he would on no account have the hives removed. Every second or third bush had a large hive such as I have described, and one portion of the garden looked almost black owing to the immense quantity, large and small, of the hives borne on the branches.

Ants are not Beneficial.

It was useless my saying that I was willing to undertake to collect as many pests in his garden as could be found in any other in the neighbourhood selected for the purpose of comparison. He believed in ants, and there was no getting beyond that fact. My visit lasted for an hour or two only, but I examined the bushes with considerable care to see if they enjoyed any special immunity from blights and pests. I could see no difference between that garden and the one or two neighbouring gardens I had been recently investigating.

497. Depredations.—As this ant is very frequent in Assam tea gardens, I took some little trouble to study it during the repeated occasions I came across it. A very large number of small nests will generally be found constructed on bushes badly affected by the Tea Aphis **(Ceylonia theæcola).**

Method of Imprisoning the Tea Aphis.

The head and thorax of the ant are of a bright brick-red colour; it has two sharp spurs on either side of the middle portion of the "alitrunk" or first abdominal section attached to the thorax. The abdomen proper is of a somewhat triangular shape, pointed at the anal extremity, and, during the act of running, is carried in a strikingly erect and threatening attitude. Up and down the shoots these clever little ants may be seen to be traversing while paying their attentions to the aphis. Far, however, from eating that particular tea pest, they protect and even imprison it; for this purpose they carry up some of the material of which their hives are formed and cement the leaves of the shoot around the aphis. It seems probable, therefore, that new ant nests are formed around colonies of that aphis. It is the sweet exudation of the aphis that they are after, and they thus protect, rather than kill, the pest. I did not, however, come across a **Lecanium** or other scale-insect imprisoned, as **Mr. Green tells us is** the case with the Ceylon ant. (*Conf. with p. 333.*)

RED-BLACK ANT.

Injury effected.

498. But they become pests themselves and of a serious nature. They injure the bark on the portions of the branches within their hives, to such an extent that the circulation of the sap is checked, the parts projecting above the hive are accordingly starved and rapidly die. On no account, therefore, should these ants be allowed to get established in tea gardens. The injury they do to the tea plant far out-weighs any possible help they may render, and their hives should accordingly be cleared off every bush upon which they are found.

59. (c) Œcophylla smaragdina, *Fabr.*

THE RED ANT OF ASSAM.

RED ANT.

499. HISTORY.—This is the common ant, seen on trees all over the province. It draws together a mass of leaves and unites them by a fine white silken web into a hive. It is capable of biting with considerable severity on being disturbed, and is accordingly a source of great annoyance to the women while picking tea leaf. It is no doubt a carnivorous insect, and might do good, but is distinctly objectionable. Besides which it cannot be healthy for the tea bush to have a clump of its twigs and leaves, perhaps 2 feet in length and breadth, tied up in the manner indicated. Flushing with that portion of the bush is quite out of the question, and I am much disposed to think that the two or three adjoining bushes, to a red ant's nest, are very likely to be neglected both by the pluckers and the hoers.

Source of Annoyance and Loss.

500. REMEDY.—The best way to get rid of both above species of ants is to place a small box over the hive and light a basin of flour of sulphur below. The majority of the ants will be killed, and in the morning the hive may then be cleared off, or the branch bearing it may be cut off.

60. (c) Wasps.

WASPS.

501. Various species of Wasps are occasionally found on the tea bushes, and should be killed and their hives removed in the manner described for ants. A small nest of red ants, lopped off and placed at night against a wasp's hive, will, I am told, be found an excellent method of dealing with wasps. Two or three ants attack each wasp, and in a few hours' time the entire swarm will be found dead.

ACRIDIUM PEREGRINUM.

ORTHOPTERA.

LXIII.—The Grasshoppers, Crickets, Locusts, etc.

502. As the name ORTHOPTERA implies, these insects have the wings folded lengthwise, the lower wings being closed fan-like beneath the upper pair. The body is more or less cylindrical, and the forelegs very often formed for burrowing in the ground. They accordingly dig holes, many of them living very largely on larvæ and worms, others on roots, fruits and leaves. The Locust is, perhaps, the best known defoliator of this assemblage of insects, but to the tea planter the cricket is the most serious pest of the Order. It would seem probable that there may be two or three species of Cricket, though I only met with one in Assam.

61. (a) Acridium peregrinum, *Oliver.*

62. (a) Acridium flavicorne, *Fabr.*

63. (a) Catantops indicus, *Saussure.*

LOCUSTS.

LOCUSTS.

503. HISTORY.—Particulars are given by Mr. Cotes (*Insects and Mites, etc., pp. 43-44*) of the above species. As I did not come across these pests during my brief explorations in Assam, I do not think it is necessary for me to do more than mention the fact that they have been known to injure the tea. Mr. Peal in a letter to the *Tea Gazette* says, "Lately part of my garden was taken possession of by many thousands of Locusts, apparently the same as those I have seen in flights in the hills of the North-West." "These insects did not feed on the tea, but they seemed to prefer the bushes to live on, and did a considerable amount of damage by walking over and apparently mouthing the young leaves, which, whenever the locusts touched them, turned black and curled up."

Larval Stage.

504. Mr. Cotes concludes his account of locust thus: "Acridiæ of this kind are likely to lay their eggs in the ground. The larvæ are active grasshoppers, which differ from the adult chiefly in being smaller in size and wingless. They are active throughout their entire existence, and devour the leaves of plants in large quantities."

64. (a) Brachytrypes achatinus, *Stoll.*

CRICKET.

THE CRICKET.

References.—*Journ. Agri.-Horti. Soc. Ind., Vol. I. n. s., 1869, Proc. 19th Feb., p. xiii; Tea Cyclopædia, 40 Money, Tea Cultivation,*

89-90 ; Baildon, Tea in Assam, 46 ; Notes on Tea in Darjeeling, 55; Ind. Mus. Notes, Vol. III. (pt. 5), 77 ; Cotes, Insects and Mites, etc., 45. CRICKET.

(Reg. No. 114.)

505. HISTORY.—The earliest mention of the Cricket as a tea pest occurs in a letter of **Mr. Peal's** to the *Agri.-Horticultural Society of India, dated 1869.* A little later **Mr. Peal** wrote a paper on tea pests (that will be found in the *Tea Cyclopædia*), but omitted to mention the Cricket. Whereupon a Cachar planter wrote to the *Tea Gazette* drawing attention to this as a serious omission. **Colonel Money** devotes only a few lines to the subject of pests under the heading of " White-ants, Cricket and Blight." The fourth edition of his work appeared in 1883, so that even fourteen years ago the subject of pests and blights was regarded by the author of the Prize Essay on tea as practically of no moment. He, however, tells us that the cricket was very destructive to seedlings. The same opinion has been given by **Baildon** and by the author of *Notes on Tea in Darjeeling (1888).* **Mr. Cotes** mentions that the only occasion on which representatives of the insect had been sent to the Indian Museum was in July 1893 and from Jorhat in Assam. The figure (*p. 45*) given by **Mr. Cotes** is of the immature insect, and is little more than one-half size of the full-grown cricket. **Mr. Bamber** makes no mention of the cricket, and **Mr. Crole** (1897) confuses it with **Lachnosterna impressa.**

The cricket was collected by me in at least a dozen nurseries and young plantations, here and there all over the province. **Mr. W. H. C. Whigham,** of Hautley, Golaghat (to whom I am indebted for much valuable assistance), has sent me a dozen or more of the full-grown cricket and in excellent condition. It will thus be seen that the cricket is a very widely distributed tea pest, but so far we have apparently no mention of it from the Duars, Darjeeling, Kumaon, Kangra, nor from South India. **Colonel Money's** remarks may possibly be accepted as having special reference to Chittagong. There would seem every likelihood, however, that, although no special mention occurs of this pest outside Assam and Cachar, it possibly occurs throughout the Indian tea districts.

A Very Widely Distributed Pest.

506. I have already remarked under **Agrotis ypsilon (A. suffusa,** *Cotes, Insects and Mites*) that the black grub may, in some instances, be the actual depredator, in some few instances where blame has been laid on the cricket.

Possible Errors.

Orthoptera.

BRACHYTRYPES ACHATINUS.

Kills Seedlings.

507. DEPREDATIONS.—Both these insects (the black grub and the cricket) have the same vicious habit of living in nurseries or new plantations. During night they emerge from their burrows to eat off the young stems. The seedling, in the majority of cases, is thereby killed. The Cachar planter to whom reference has been made above, wrote that "the Cricket is both common and very destructive in Cachar. It is about 1¼ inch in length when full grown, and lives in small burrows sometimes singly, sometimes two or three in one hole. The burrows frequently penetrate to a great depth, and where the crickets are so numerous that it becomes necessary to dig them out (which sometimes happens), the tunnels are followed a foot and a half or two feet, and even then not uncommonly without avail. The cricket feeds on the young leaves of the young plants; and to obtain these, it cuts through the stem of the plant, about three quarters of an inch from the ground, and then carries off the top to his hole, so that each meal which the insect makes causes a vacancy; where they appear in any number the destruction may be imagined. They will cut through a stem as thick as a pencil without difficulty, and amongst small plants in a nursery they sometimes do incalculable mischief. I have seen them attack an old plant, where they eat off the young shoots, and thus did a great deal of harm to the succeeding flushes; but I have only once seen this occur."

Sometimes Do Incalculable Mischief.

Sometimes Attack Old Plants.

508. The Director of Land Records and Agriculture, Assam, furnished the samples above alluded to, as sent from Jorhat to the Indian Museum. The following passage from the report on these may be taken from the *Indian Museum Notes*, in amplification of the above letter from Cachar. "The creature was observed to be specially abundant on sandy soil. If makes burrows from 9 to 18 inches deep in the ground, where it conceals itself during the day-time. In the evening it sits at the mouth of the hole, and may be recognized by its shrill piping."

Specially Abundant on Sandy Soils.

Method of Capture.

509. REMEDY.—So far as I know, there is only one way of dealing with this pest, namely, that generally pursued in Assam, namely, reward to the children to catch the insect. And they do this very cleverly. Armed with a straw or long flexible twig and a piece of bamboo, by way of a spade, they proceed to the nursery or new plantation. Having found a likely hole they insert the straw as far as it can go, and then proceed to dig down (following the straw) till they

come on the cricket. It might be desirable to substitute a soft copper wire for the straw, and, if properly used, the wire might even kill the cricket. Its use would not in any case necessitate such care to avoid cutting the guide, as is the case with a straw or twig. Poisonous fluids poured down the holes might also be effectual. In Europe the mole-cricket is captured by burying in the ground flower pots or other vessels with smooth sides—mouth upwards. The crickets fall into these at night-time and cannot escape.

THE CRICKET. A Wire Useful.

Traps.

510. The life history of the Indian species has not been worked out, so that we do not know when the breeding season occurs. The eggs are laid in small caverns underground no doubt, as is the case with the English mole-cricket. It would be an effectual method of dealing with the pest to have every hole traced out and the eggs discovered and destroyed at the breeding season. The female generally keeps watch at the mouth of the tunnel leading to the eggs, and the larvæ very possibly take more than one season to reach maturity.

Desirable to Know Breeding Season.

Destroy the Eggs.

It is most desirable that we should obtain full particulars of the life history of the Indian cricket, in order to be able to suggest methods of treatment.

HELOPELTIS THEIVORA: HISTORY.

CHAPTER XIII.

HEMIPTERA OR RHYNCHOTA.

LXIV.—*Tea-Mosquito, Green-fly, Aphides, Plant-Lice, Scale-Insects, Plant-Bugs, etc.*

511. Under this Order I propose to deal with the HOMOPTERA and HETEROPTERA of Entomologists, without making more than a popular distinction between these sub-orders. Some of the most serious tea pests fall within this assemblage, namely, the Mosquito, Green-fly, Tea Aphis, and Scale-insects. The term "Bug" has at different times been applied by planters, to almost every member of the Order, though the true plant-bugs constitute the HETEROPTERA only, a comparatively small group of the entire assemblage.

Family CAPSIDÆ.

65. (a) Helopeltis theivora, *Waterhouse.*

BLIGHT OR TEA BUG.

The TEA MOSQUITO—originally called "BLIGHT," and subsequently the "TEA-BUG."

References.—*Report, Commissioners appointed to enquire into State and Prospects of Tea Cultivation in Assam, Cachar and Sylhet, 1868, p. 3; Peal in "Englishman," 18th Sept. 1872; 20th March 1873; 12th Sept. 1873; Journ. Agri.-Horti. Soc. Ind., n. s., Vol. I., Proc., Jan. 20th, 1869 (Blight in Cachar), p. vii; Vol. III., p. 221; Vol. IV.; Peal, the Tea-Bug of Assam, pp. 126-132, with coloured plates; Proc., 27th Feb. 1873, p. vii; Proc., 20th Nov. 1873, pp. xlv-xlvii; Vol. V., Dr. C. Aleyboom, "Roest" (Rust) on Tea Plant, pp. 55-61; Proc., 15th April 1874, pp. xvii-xix; Proc., 25th June 1874, pp. xxvii-xxix; Proc., 30th July 1874, p. xxxvii; Proc., Aug. 27th, 1874 pp. xlv-xlvi; Proc., 24th Aug. 1876, p. xxvi; Vol. VI., Proc., 18th Dec. 1879, p. xli; 22nd July 1880, p. xxi; Vol. VII., Proc., 28th Oct. 1885, p. clxxxv; Proc., 30th Dec. 1885, p. cxcv; Vol. IX., 24th Nov. 1893, pp. cdvii-cdx; Tea Cyclopædia, pp. 36, 37, 46, 47-49, 50-54; Stoker, Notes on the Management of Tea in Cachar (1874), p. 19; Money, Tea Cultivation, fourth edition, July 1883; (Also original Prize Essay, Agri.-Horticultural Soc. Journ., Vol. III., 1871, p. 221); Baildon, Tea in Assam (1877), p. 45; Official Correspondence on the Deputation of Wood-Mason to Assam, 1880-1881; Wood-Mason, Report on Tea-Bug in Assam (1884), pp. 12-20; Tea Planter's Vade Mecum (1885), Tea-Bug., pp. 100-102, Mosquito 103-104; Notes on Tea in Darjeeling (1888), p. 51; Green, Insect Pests of the Tea (1890), pp. 71-81; E. T. Atkinson (? 1890) (Rhynchota) in Indian Museum Notes, Vol. I., (pt. 4), pp. 175-186, plate XII.; L. de Nicéville, l. c. pp. 197-198; Bamber, Chem. & Agri. of Tea (1893), pp. 245-248, Ind. Mus. Notes, Vol. II., pp. 43, 166; Vol. IV., p. 42; G. C. Dudgeon*

in Indian Mus. Notes, Vol. III., (pt. 5), pp. 33-38; Miles, Bulletin Micro. Soc., Calcutta, Vol. IV., July 1895, pp. 40-44; Christison, Home & Colonial Mail, 1st Jan. 1897; Crole, Tea Text-Book, pp. 82, 223.

(*Reg. No. 1, tubes (red form) Nos. 6, 135, 164, 229, 231, 237, 244, (green form) 126, 182, 220.*)

TEA MOSQUITO: HISTORY.

History.

512. ***First Mention of Blight.***—The facts regarding the appearance of this, the most alarming of all Indian tea pests, may be said to be fully indicated by the above citation of papers, reports and letters, that have appeared. It seems to have been first noticed in Cachar about 1865. The Report of the Commissioners appointed by Government to enquire into the state and prospects of Tea Cultivation, informs us that "heavy losses from blight in 1865 and again in 1867" had been sustained. "It is said to show itself in the end of June or July, and to continue more or less to the close of the season. The circumstances of its appearance and progress have not been noted with the accuracy necessary to enable us to form any opinion of its nature." "The loss from this cause in the gardens of one company in 1867 was estimated as high as 50,000 lbs. of Tea. It is a singular fact that blight is almost, if not entirely, confined to that part of Cachar which lies to the south of the Barak River."

First Recorded South of Barak River: 1865.

513. ***Early Allusion to it in Darjeeling.***—The next historic incident to which attention may be drawn, is a correspondence given in the Proceedings of the Agri.-Horticultural Society of India, for the 20th January 1869. Dr. Thomas Anderson (Superintendent, Royal Botanic Gardens, Calcutta) sent certain samples to the late Rev. Mr. Berkeley. These consisted of specimens furnished by the late Mr. S. E. Peal, of Assam, under the name of "Black Smut or Rust," and another set by Messrs. Jardine, Skinner & Co., from one of their Cachar gardens. Regarding the latter Mr. Berkeley said, he could find no fungus, but the former, he thought, might be a species of Asterina. In submitting this report to the Agri.-Horticultural Society, Dr. T. Anderson remarked that since he had sent the samples to Mr. Berkeley he had himself observed the disease called "Blight" by Cachar planters on some tea plants at Darjeeling. "He had carefully examined the bushes and could find no diseased leaves in any other stage of the disease, but that forwarded to Mr. Berkeley. He, however, found several leaves with a small insect lying under the epidermis of

Early Mistakes.

Cachar Blight not Fungoid.

HELOPELTIS THEIVORA: HISTORY.

the leaf, and he supposed that this insect must have devoured the parenchyma, and caused the transparent spots (blight) with which the leaf was covered. Dr. Anderson exhibited some of these leaves with the insect in position; also a few leaves with minute eggs of an insect, collected in patches on the surface of the leaf. Dr. Anderson said that he found many of the indigenous plants in the forests, adjoining those tea estates in which blight had been observed, were also affected. He particularly noticed **Gordonia Wallichii,*** a Ternstrœmiaceous plant nearly allied to tea, a **Polygonum,** an **Osbeckia** and **Mæsa montana** as suffering much from the blight. Dr. Anderson shewed young leaves of **Cinchona succirubra** from a tea estate at Darjeeling; these leaves were covered with the blight spots."

Found in Darjeeling in 1869.

Mæsa. Conf. with para. 10.

First Suggestion of Insect Origin.

514. I have given the above passage in full, as I think it is of great historic value. Dr. Anderson was the first observer to suggest that the blight was in all probability caused by an insect. He made a mistake, however, in associating a leaf-mining insect (possibly **Oscinis theæ**) with it, so in a like manner the "patches of eggs" that he discovered were very possibly the male scales of **Chionaspis theæ.** A similar mistake, no doubt, had been made in sending to Mr. Berkeley leaves with "black smut" as it was called, since these leaves in all probability contained one of the numerous species of Coccidæ with its associated fungus, but which had nothing in that case to do with mosquito. There remains, however, as I take it, the unmistakable fact that Dr. Anderson found in Darjeeling mosquito puncturings on Tea and Cinchona as early as 1869. It is also significant that he should have drawn attention to the very similar puncturings that we know are caused by allied insects, on **Mæsa** and **Polygonum.** But **Schima Wallichii** has only once, since the date of Dr. Anderson's observations, been recorded as being so punctured, namely, by Mr. C. N. Harcourt, *Ind. Mus. Notes, Vol. II., (pt. I), p. 43.* **Schima** is a closely allied plant to the tea, and it is, therefore, just possible that all subsequent observers have made a mistake in not giving this subject more careful study.

Interest in Schima.

A Blight Peculiar to Cachar.

515. The next fact in historic sequence is Colonel Money's reference to "blight" in his *Prize Essay* published originally in 1871. He there tells us :—" Blight (a serious matter I hear in Cachar) I know

* **Schima Wallichii,** *Choisy,* as it is now called.

but little of. I do not remember hearing anything about it, when I was there, now six years ago." The date thus given for the appearance of the pest corresponds with that already mentioned, namely, 1865. The volumes of the Agri.-Horticultural Society of India from 1872-1877 may be said to literally teem with papers and letters from planters and others on the subject. **TEA MOSQUITO: HISTORY.**

516. ***Identification of Insect.***—To Mr. S. E. Peal belongs both the credit of having awakened interest in this insect and of having himself written perhaps the best account of the methods of depredation effected by it, that exists even to the present day. "*The Tea-Bug of Assam,*" with seven coloured plates, will be found in the fourth volume of the Agri.-Horticultural Society's Journal. Ten years later Mr. J. Wood-Mason paid Mr. Peal the compliment of saying that, in his opinion, the Society "did not spend as much money as the beauty of the drawings and the importance of the subject demanded." Mr. Peal did not give the insect its scientific name, and he did not discover its method of depositing its eggs on the tea shoots, but in every other respect his paper contains very nearly all that we at present know of a practical nature regarding the pest. Shortly after the appearance of Mr. Peal's paper, Dr. C. Aleyboom, of Java, contributed to the Agri.-Horticultural Society a translation of an article he had written "a few years ago," in which it would appear, after testing every aspect of the disease that seemed to suggest a fungoid origin, he had arrived at the same conclusion as Mr. Peal, namely, that it was caused by an insect, though he neither named nor described it. **Discovery in Assam.** **Discovery in Java.**

517. Mr. Peal, in the same journal, published a letter in reply to some of Dr. Aleyboom's observations. He also furnished samples of the insect, and these were forwarded to England for the inspection of Entomological experts. A copy of Mr. Peal's letter to the (*Englishman, 18th September 1872*) was forwarded to Mr. Grote along with the specimens, and these were ultimately submitted to Mr. F. Moore. **Insect named by Mr. Moore.**

In the Proceedings of the Society for 20th November 1873, Mr. Melville Pike, of Serispur Tea Factory, Hylakandy, Cachar, is stated to have forwarded samples of the mosquito. These were accompanied with a most instructive letter that gives many useful details; amongst others, he says that the insects are amber-coloured, but become green on their being distended with the sap. He then proceeds **Become Green after Feeding.** *Conf. wit para. 573 (p. 291).*

HELOPELTIS THEIVORA: HISTORY.

to give particulars of the time taken for the insect to reach maturity and the number of punctures a full-grown insect is capable of inflicting per day.

518. **Mr. Grote's** reply as to the name of the insect furnished by **Mr. Peal** (*Proc., 15th April 1874*) informed the Society that **Mr. Moore** had identified it as a species of HELOPELTIS (a genus of CAPSIDÆ) of which four species as yet are known, one from Ceylon and two from the Indian Archipelago. The Assam form is thus the fourth, and it much resembles that from New Guinea. From its feeding on the juice of the tea plant **Mr. Moore** adds—"I have named it **Helopeltis theivora.**"

Professor Westwood's Paper.

519. In the Proceedings for 25th June 1874, further particulars regarding the insect are given. Samples had been submitted to **Professor Westwood** who wrote a paper on it, the only additional point of historic interest being the fact that the Java mosquito had been examined and named in 1871. In 1874 **Mr. Peal**, who had been asked for a further supply of specimens, reported that "curiously enough the bug is not here this year, the early and unexceptionally heavy wet may have something to do with it." Later on, 27th August, he again wrote, "I now find I was rather premature in this, as they are again causing damage. This year they seem to have shewn later than usual."

Rediscovered in Darjeeling.

520. One of the earliest direct reports on mosquito in Darjeeling District will be found in a letter from **Messrs. Lloyd & Co.,** Agents for the Chenga Tea Company, 28th October 1885.

Scientific Investigations.

521. ***Scientific Investigations Required.***—This leads naturally to the period of the official correspondence regarding the late **Mr. J. Wood-Mason's** deputation to Cachar, in order to study the "tea-bug," and to suggest the best means for destroying the pest. **Mr. J. Wood-Mason's** explorations took place from March to November 1881, and his *Report on the Tea-Mite and the Tea-Bug of Assam** appeared in 1884. Some of the particulars, regarding which it was desired to obtain information, as set forth in the correspondence, may be here usefully abstracted from these official papers. In their letter to the Government of India, the Calcutta Tea Agents asked for the services of both

* It would have been more correct had this been called *The Tea-Bug of Cachar,* since apparently **Mr. Wood-Mason** did not visit Assam proper.

a botanist and an entomologist. They stated that information was desired on the following points:—

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1st.—The nature of the insect.
2nd.—Its manner of propagation.
3rd.—Its time of propagation.
4th.—Its place of propagation.
5th.—The stages of its existence.
6th.—The stage in which most easily destroyed.
7th.—The most effectual modes of its destruction.
8th.—Whether modes of pruning, plucking and cultivating the bushes, etc., are not at fault, and what changes in these directions would be likely to have a beneficial effect.

Subjects of Information still Desired. *Conf. with para. 538, 555.*

522. It seems somewhat unfortunate that it did not occur to Mr. Wood-Mason that it would be desirable to attempt to trace out the history of the pest. He does not mention the gardens where he found it, nor those in which he did not find it. He makes no reference to the annual date of appearance and disappearance. He disposes in a few words of the suggestion of its possible association with particular soils, with shade, or with methods of cultivation. These, he says, are not singly nor collectively causes of the disease. He discovered its method of depositing its eggs on the young shoots—a practical fact of great importance—but he does not venture on a suggestion even, as to its method of hibernation—the period when in all probability it could be most easily assailed. In the official correspondence prior to his deputation to Cachar, Mr. J. Wood-Mason laid before the Government of India a paper of Professor Ray Lankester's (which had appeared in *Nature*) on the subject of the possibility of attacking the insect pests of crops, by communicating to them the spores of destructive (parasitic) fungi. But in the report of his investigations Mr. Wood-Mason makes no further allusion to this subject, nor to his having discovered any of the natural enemies of the mosquito.

Discovery of the Ovipositor. *Conf. with para. 536.*

Natural Enemies. *Conf. with paras. 542, 566-71.*

523. ***Discovery of Insect in Ceylon.***—The next paper on mosquito that need be here mentioned is one by the late Dr. Trimen (*Nature, Vol. XXX., (1884), p. 634*) which gives particulars of the depredations on Cacao and Cinchona of **H. antonii.** This may be said to

Discovery of Mosquito in Ceylon.

HELOPELTIS THEIVORA: HISTORY.

Various Species of Helopeltis.

have been followed by Mr. E. E. Green's most excellent account of the appearance of that insect on tea in Ceylon.

524. ***The Species of Helopeltis.***—The late Mr. E. T. Atkinson (*Ind. Mus. Notes, Vol. I. (pt. 4), 175-186*) published a review of the known species of **Helopeltis**, some ten in number; one, the Ceylon insect, **H. antonii** already mentioned, two found in India, *viz.*, **H. theivora** and **H. febriculosa**, and the remainder in Java, New Guinea and the Philippines. One of the most interesting side issues of Mr. Atkinson's paper may be said to be the mention of a possible natural enemy to the mosquito, a Reduviid that had been discovered by Mr. W. L. Distant among some Ceylon samples of **H. antonii.** The plate furnished by Mr. Atkinson gives illustrations of four of the species of **Helopeltis**, the figures of **H. theivora** being exceptionally beautiful and accurate.

Possible Natural Enemy. *Conf. with para. 566.*

Method of Depositing Eggs.

525. ***More Recent Investigations.***—Perhaps the next Indian papers of importance are those by Mr. C. N. Harcourt (*Ind. Mus. Notes, Vol. II., 43*) and by Mr. G. C. Dudgeon (*Ind. Mus. Notes, Vol. III., (pt. 5), pp. 33-38*). Both these writers deal with the method of depositing eggs on the young shoots. But Mr. Dudgeon adds several interesting additional details. A point of special value may be here alluded to, in Mr. Dudgeon's paper, *viz.*, where he tells us that the abdomen, in fresh specimens of both sexes, *is invariably bright emerald green*, marked dorsally, on the third to ninth segments, with shiny dark brown. So again, he continues, the larvæ are greenish with deep ochreous or orange legs and antennæ. He further discusses the question of the puncturings, similar to those on tea, that are to be seen on jungle plants, such as on **Mæsa indica,** and adds that, so far, none of these have proved to be caused by **Helopeltis theivora.**

Green Colour of Abdomen.

526. Lastly, Mr. Cotes' account of this insect, in *Insects and Mites of the Tea Plant in India (pp. 29-33)*, may be characterised as a useful review of the literature of this pest, but one which furnishes no additional information. It may further be pointed out that the insect as figured by Mr. Cotes differs in certain respects from Mr. Atkinson's most excellent plate, for example, both the legs and antennæ are shown by Mr. Cotes as very hairy, while they are quite glabrous in the drawings furnished by Mr. Atkinson. The object I have in directing attention to these particulars may be at once stated, *viz.*, that I suspect

Hairs on the Legs and Antennæ.

there are two forms of mosquito met with in Indian tea gardens, and that the drawings mentioned practically represent these.

TEA MOSQUITO: DESCRIPTION.

527. ***Conclusions.***—To conclude this brief historic review of the early literature of the subject, it may be said that it is significant that a form of the so-called tea mosquito should have simultaneously appeared in Cachar and Assam, namely, from 1865 to 1868. If we can accept Dr. T. Anderson's observations as pointing to mosquito, then the insect would seem to have appeared about the same period in Darjeeling. We next hear of it in Java and subsequently in Ceylon.

Description.

528. ***Explorations in Assam.***—During my explorations in Assam, I came across the mosquito here and there all over the province. It appeared, disappeared and re-appeared in the most perplexing manner. One garden would be found practically stopped through this pest, while a few miles off another garden could hardly be said to have any mosquitos. In every garden where it was found to an injurious extent, women and children were employed to collect the insects. At the end of the day's operations the collectors returned and an estimate was made of the sum due to each. For several weeks on end I must have seen and examined many thousand mosquitos almost daily. They were all of a bright orange-red colour, almost pink in the very young larval stage, but deepening with age, the males becoming almost black in general colour. Mr. Peal's plates are, if anything, too yellow for the insect as seen by me; Mr. Wood-Mason gives no description of the insect he investigated in Cachar.

Distribution in Assam.

Orange Red Colour.

529. ***Green Colour of Mosquito.***—Prior to my visit to Assam I had read the passages alluded to above, where the mosquito is said to turn green on its absorbing the tea sap. As I had failed to find any examples of that colour, I was surprised and mentioned the fact to Mr. Peal. He at once said it was a mistake, that the colour deepens with age, but does not change on its sucking the tea juice. To make quite sure I had some insects placed on a tea bush enclosed with mosquito-curtain cloth, and watched them puncture the leaves, saw the brown spots gradually form on these, but never witnessed any change of colour in the insect itself before nor after its meal. I never came across a green mosquito in any of the gardens of Sibsagar or Dibrugarh. But on this very point of the colour of the

Green Colour of Mosquito.

Conf. with para. 517, 525, 573 (p. 291).

Hemiptera (Capsidæ).

HELOPELTIS FEBRICULOSA: DESCRIPTION.

insect Mr. Peal seems to have unconsciously changed his opinion without the suggestion having apparently occurred to his mind that there might be two species. Shortly after the appearance of Mr. Peal's original paper, a tea planter wrote in *The Tea Gazette*, "As to the description of the insect, on the whole I think Mr. Peal is very correct, but on a few points I think he errs; thus, for instance, he says that, when very young, it is 'of a pale green colour'; now I have examined many thousand specimens, and I have never found one of that colour yet: they are even from the very earliest stage, when little larger than the red-spider, of a brownish-red colour, and never, during any stage of their existence, become of a green colour. From the great similarity in appearance, otherwise between the young of the mosquito pest and the tea aphis, I am inclined to think Mr. Peal must have confused the two." In this connection it may be remarked, Mr. Peal certainly did make a mistake in calling green-fly an aphis.

Green-fly. *Conf. with paras. 577, 579.*

NORTH BANK MOSQUITO.

530. ***North Bank Mosquito.***—But I was greatly surprised on my crossing to North Lakhimpur (that is to say, to the gardens on the north bank of the Brahmaputra) to find the young insects of a pale emerald colour, and yellowish green with faint brown markings in the adult condition. At Patalipam, visited in July 1895, I could not find an orange-red mosquito on the tea, though I was told a red insect was occasionally met with. This led me to compare my collections of red mosquito with the live green ones. They differed in several respects.

Naked Shining Red Form.

The orange-red insect, in its mature state, was seen to be larger than the straw-coloured form. It was observed to be very nearly glabrous (that is to say, had few, if any, hairs on the body, legs, or antennæ), and the abdomen was of a bright shining dark orange-red with black bands on the five terminal segments. These bands, at least the last three, could hardly be called dorsal, however, since they were seen to be nearly as deep in colour on the belly as on the back of the segments.

Hairy Green Insect.

The green and straw-coloured insect, on the other hand, was noted to be considerably smaller and very much more hairy, than the red form, especially on the lower portions of the legs, and on the antennæ, while the drumstick-like spine on the scutellum was observed to be almost bristly, both on the shaft and on the knob. A pale-coloured

lateral line was also noted as extending across the dark dorsal bands of the last three segments, and the belly was pale straw-coloured. The males seem to turn quite black and the wings to become nearly twice the length of the body.

TEA MOSQUITO: DESCRIPTION.

Effect on Plant.

531. These characters may not of course suffice to justify their separation as two species, but I still further observed that the effects on the plant, of the puncturings of the green insect, were very different from those of the red. Whether, therefore, they be regarded as varieties or species, the isolation of the two forms seems to me worthy of consideration.

532. It was accordingly with no small interest that I examined the type samples preserved in the Indian Museum. The first series that attracted my attention consisted of samples sent from Darjeeling by **Sir G. King** as having been found on the Cinchona. These were undoubtedly identical with my North bank Assam insect. **Mr. Atkinson** tells us that certain samples of mosquito collected by **Mr. Gammie** at the Mungphu Cinchona plantations, had arrived at the Museum, and that he had sent these to **Dr. Bergroth** for identification. The insect in question had proved to be **Helopeltis febriculosa,** *Bergroth.* The description of that species answers very nearly to my North bank Assam insect The tibiæ are spoken of as clothed with slight somewhat hispid hairs; the abdomen is said to be sub-virescent; and the rostrum sparingly thinly pilose, etc.

Darjeeling Insect.

533. Whether the whole of the mosquitos of the Darjeeling tea districts should, from the circumstances narrated, be assumed to be **H. febriculosa** may be open to some doubt, but, it will be observed, **Mr. Dudgeon** speaks of the abdomen as being bright emerald green. The point is worthy of further enquiry since it is certainly significant that the green insect should be practically unknown in the gardens of the South bank of Assam, while it is fairly abundant on those to the North.

Patalipam Mosquito.

534. But I must hasten to add that the other day (July 1897), I asked the superintendent of Patalipam to kindly furnish me with a fresh supply of the green mosquito I had found there in 1895. His reply is most instructive. The green insect had been getting more and more scarce every year, and the red one taking its place. He furnished me with samples, and quite half were the red sub-glabrous insect with black or rather brown-black terminal abdominal segments.

HELOPELTIS THEIVORA: GENERATIONS and HIBERNATION.

It may, therefore, I think, be suggested that the green insect was the one that first appeared, and that the story of its turning green on its having had a meal arose from the two forms being confused one with the other.

Annual Generations and Period of Hibernation.

535. I regret to say that the shortness of my explorations in Assam prevented me from instituting any very practical investigations into these all-important points in the life history of the mosquito. It may, however, be useful if I bring together all the facts that have been ascertained. Mr. Melville Pike gave (1873) the following particulars: "The insect on growing older and increasing in size assumes a deeper amber or orange colour: after moulting their skins, the antennæ get longer and turn to a black colour, is less active in moving or flying about in its perfect state, and is provided with wings of a dark (approaching to black) colour."

The Ovipositor. *Conf. with para. 522.*

536. ***Discovery of the Ovipositor.***—The most important part of Mr. Wood-Mason's investigations was doubtless the discovery of the method and place of deposit of the eggs. After giving a passage from Mr. Peal's report, descriptive of the course of depredation, he continues:—

"It was reserved for me to discover the manner and position in which the tea-bug lays its eggs; and a brief but sufficient account of my observations is given in the following communication addressed by me on June 8th, 1881, to the Chief Commissioner of Assam, by whose orders it was published in the *Assam Gazette*, for general information:—

537. "***Tea-Bug.***—Have discovered, by observation of specimens of this formidable pest kept in confinement, that the female deposits her eggs singly in the substance of the tenderest shoots of the plant, in the *internodes* or portions of the stem between the pekoe and the two or three leaves succeeding from above downwards, and in the buds developed in the axils of plucked leaves and in the parts thereabout; that the presence and position of each egg is from the first indicated on the exterior by two unequally long, glistening white, bristle-like prolongations of its shell, and later by discoloration of the point pierced. Have discovered by dissection that she is provided with a serrated ovipositor, of the shape and sharpness of a sabre, wherewith to pierce holes in the soft tissues of the plant for the reception of her eggs. These

Bristles of the Egg.

observations have been verified in the field upon numerous blighted bushes; but, though eggs have readily been found by the unaided eye on blighted portions of bushes, not a single one has yet been seen on any perfectly uninjured shoot. The vigorous and unremitting plucking of the blighted portions of bushes might mitigate the evil;* and I would suggest that this message be sent to newspapers and published in the *Gazette* for general information."

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538. "The agents and owners of tea-estates had always attached the greatest importance to the discovery of the eggs, as they hoped by the destruction of these to effect the extermination of the pest, or at least a diminution of its numbers; and with the view of assisting the planters in finding out in what part of the plant the eggs were deposited, long before I visited Assam I had suggested that eggs or viviparously produced young should be sought on the young and tender shoots. Some time before my mission was arranged, I received from Mr. Alexander Wilson several microscopic slides, which, that gentleman informed me, were supposed to contain viviparously produced young taken from young shoots by one of his *employés*, who, I think it was stated, had actually witnessed their birth on the shoots."

Discovery of the Egg. *Conf. with para. 591.*

Viviparous Reproduction.

539. "These slides proved on examination to contain ripe eggs, which had evidently been taken from the bodies of females and not from the plants at all—the preparer of them having evidently mistaken the two unequal processes which spring from the mouth of each egg for antennæ, and hence jumped to the conclusion that he had found fully formed embryos ready to be deposited alive upon the bushes. Though I never succeeded in finding embryos in eggs extracted from the bodies of females, it is possible, but highly improbable, that under certain circumstances such may occur, that eggs may be retained by the females until development is far advanced, and be inserted in this condition in the usual manner into the substance of young shoots, just as undeveloped eggs are."

540. "The knobbed ends and also the sides of the two tubular processes of the mouth of the egg-shell, to a greater or less extent, are studded with button-shaped elevations, each of which has a minute pit in its centre. These pits are probably the ends of minute tubules which place the lumens of the processes in direct communication with the exterior, and thus serve to carry air to the developing ovum. The

Tubular Processes of the Egg.

* *Conf. with paras. 543, 545, 560-1.*

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eggs are provided with deep saucer-shaped lids, perforated, sieve-like, with holes which are large enough to admit the spermatozoa."

541. "In order that the reader may form some idea of the numbers of the eggs, I may state that, on one occasion I counted more than forty eggs in twelve shoots taken consecutively and at randum from a plucker's basket; and that on another occasion I selected and plucked from one bush of a plot of tea, which was only moderately blighted, four shoots with one or more eggs in each. The females appear instinctively to avoid puncturing the shoots or the parts of the shoots in which they lay their eggs, for one can rarely find eggs on badly injured shoots."

Eggs not Deposited on Punctured Shoots.

542. ***Period Required for Larval Growth.***—Mr. Harcourt says, "The eggs are laid in the soft stems of the tea shoots, and can only be discovered from the three small hairs which are attached to each egg and which protrude from where it lies. The eggs are about one-thirty-second of an inch in length and very slender. When first laid, they are hard and white in colour, but they become red before hatching. The larva becomes full grown in about a week after emerging from the egg; and it has the characteristic bug-like odour and the only animal noticed to attack it is a small spider." A writer in the *Tea Gazette* says, "The rapidity with which the wings are developed is something wonderful:—with one specimen which I had imprisoned for about seven days no wings were visible; then, two little embryo ones like minute quills showed themselves; and after these had remained about three days, the full four wings were developed apparently at once. Certainly, late one evening no wings were visible, only the little stumps of quills, and in the morning the four wings were fully developed and the insect had changed from brown to black." "While in the larval stage they are all alike, except in regard to size, but when fully developed two different kinds appear—one a slim delicate sort of fellow all black, the other with an orange hump between his shoulders and with a dirty white abdomen. The former is the male, and the latter the female."

Colour of Eggs.

Spider Attacking Mosquito.

Conf. with paras. 522, 566, 570.

Formation of Wings.

543. ***Hibernating Eggs.***—Mr. Driver, as quoted by Mr. Atkinson, says, "I think the eggs are laid at the points where new shoots spring from the older stems and that they are hatched in March, just about the time the new shoots begin to grow. They go on breeding during the rains, but heavy rain washes them off the bushes and destroys them. These insects are indigenous in Assam, and, while in the jungles, live

Position of Eggs.

Conf. with paras. 537, 545, 560-1.

on a creeper known as the '*jangli pán*.'* The *jangli pán* leaves taste very like the *pán* of commerce. The insect is called *woohonce* by the Assamese. These insects thrive best under large shady trees, such as the rubber and wild fig." The above opinion, if confirmed, would point to hibernation being most probably by eggs deposited at the bottom of each shoot.

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Pan Leaves.

Conf. with para. 10.

Method of Hatching.

544. ***Nature of the Egg and Method of Hatching.***—Mr. Dudgeon advanced our knowledge of the subject of the deposition of the eggs on the young shoots in several directions. He tells us that two are generally placed together, so that four short stiff threads are seen protruding from the shoot. Each egg, even before being laid, possesses its own pair of these hair-like elongations. Mr. Dudgeon further tells us that, "nine or ten eggs are generally found in the body of a mature female as, owing to their large size in comparison to the insect itself, there would scarcely be room for more. It is possible that more eggs are formed as they are laid."

Eggs laid in Unpicked Stems.

545. "The eggs are at first pure white, and are generally found in the green stems of tea which have been passed over by the leaf pluckers as being too hard for manufacture. Did the insect content itself with laying in the soft green stems, doubtless it would soon be exterminated on tea gardens, where the leaf is not allowed to run out much. But apparently nature has provided against man, and the eggs are laid in the unpicked slightly hardened stems. (*Conf. with paras. 537, 560.*) Just previous to the larvæ emerging the eggs become yellowish, the inner or more spherical end being streaked with orange red (representing the legs and antennæ of the larvæ)."

Escape of Larvæ.

546. Mr. Dudgeon also made some interesting observations on the method of escape of larvæ from the eggs. They would appear to leave the lower end of the egg and to eat their way through the tissue of the shoot.

* In the extract given below from my diary (p. 291) it will be found I asked Mr. Peal about this. At the time I thought that Peal had said the mosquito lived on the wild *pán*. He repudiated ever having done so and informed me that (like myself) he had never seen it on the *pán*. In a letter recently to hand from Mr. P. J. Macdonald, the following occurs:—"This same insect is said to commit great havoc on the *pán* crop." Could this statement be true of Cachar, though certainly not of Assam? The point is worthy of careful enquiry, since it is probable the mosquito pest of tea first appeared in Cachar. I looked very carefully during many marches through miles of wild *pán*, but never saw the slightest indication of mosquito puncturings on that plant.

Rhynchota (Capsidæ).

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547. ***Hibernation in a Larval or Imaginal Condition and within the Ground.***—In another part of his paper Mr. Dudgeon alludes to the question of hibernation. "Although theories and explanations have been given," he says, "by many on this point, I have never heard of one which was not based on supposition and occasionally most absurd ones. One which is most generally believed is, that the insect retires to the jungles in the cold season to feed on other plants, when the pruners have removed from the tea bushes all the leaves and stalks that were soft, leaving it nothing there to subsist on." "My own theory regarding mosquito blight in the cold weather is, that it hibernates in a semi-dormant state near the root of the tea plant,* either in the larval or imaginal stage, and, that, as in the case of many other insects, it does not require nourishment during this period. As soon as the weather commences to get warm, its vigour returns, and it commences feeding on the young shoots and is propagated throughout the year, being observed in Darjeeling to be worst about September and October. This seems natural, as, during each successive brood, the individuals multiply until the cold weather comes, which, without doubt, kills off many, and others, in their supposed dormant state, fall easy victims to their persecutors, leaving a scattered minority to reproduce their species in the Spring. These conjectures I have not however been able to verify yet."

Hibernation in Ground.

In a letter received from Mr. P. J. Macdonald a remark occurs that may possibly be regarded as pointing to hibernation in the ground. "The blight," writes Mr. Macdonald, "shows a decided predilection for the same feeding ground year after year, and, without any apparent cause, will avoid portions of a garden which are identically similar to those annually visited."

Hibernation in Water.

548. ***Hibernation in Water.***—The suggestion has been often made, very possibly from a mistaken idea, that this pest was an actual mosquito, that it hibernates in water. It would serve no very useful purpose to give a review of the repeated occasions on which this statement has been made. As expressive of all, I may give the following:—"I believe the blight hibernates in water or swampy ground. Tea in the neighbourhood of such surroundings is invariably first attacked." It cannot of course be said hibernation in water is impossible, though I should think highly improbable.

* See the concluding remarks para. 561.

549. ***Hibernation on the Bamboo, on Tun Trees, etc., etc.***—A very large number of planters believe that the insect hibernates on the bamboo. No one has, however, either observed the hibernation or seen the bamboo leaves punctured in a manner similar to the tea. The opinion seems to have originated from the prevalence of bamboo in the jungles of Assam, when taken in conjunction with the observation that mosquito blight very often commences on the jungle end of an estate, or in out-gardens surrounded by jungle. But, on the other hand, there might of course be an allied insect to **Helopeltis theivora** found on the *Tun*, so that until the tea mosquito has been actually collected and named by an entomologist from the *Tun*, all such reports, as the above, must be disregarded.

TEA MOSQUITO: GENERATIONS and HIBERNATION.

In the extracts from my diary, given below (*p. 291*), it will be seen that Mr. Ilbert (Moran Tea Company, Sibsagar) had observed that the mosquito developed under the shade of trees, and that **Ficus** and **Cedrela** (*tun*) are the shade trees which it more especially favours. Mr. Ilbert had never seen the mosquito feeding on any jungle plant, though on one occasion, to his certain knowledge, it attacked a few **Hibiscus** plants in his flower garden.

Shade Tree.

550. The above abstract gives, so far as I am aware, all the particulars of the life of the mosquito that have as yet been learned. It is supposed that the insect takes about a week to reach maturity from the time of its escaping from the egg. If that be actually the case, the number of generations must be very great during the year. But how long does it live in the mature state, and how many eggs does each female lay? Surely, with a question of such vast importance, the remark may be pardoned that it is surprising that the planters have not themselves removed all doubt on the numerous obscure points in the life of this terrible pest. No rational effort can be made, towards a cure, until we are possessed of full particulars, and there should be little difficulty in obtaining these particulars.

Annual Generations.

551. My own inferences as to hibernation, point very much in the direction indicated by Mr. Dudgeon. In the extracts from my diary of observations, which will be found below (*pp. 293-4*), it will be observed that on several occasions gardens have been freed absolutely from this pest by having been fired. Such examples would point to hibernation being either in the ground around the tea bush, or on the bush itself. The passage quoted above from a paper by Mr. Driver

Firing of Gardens.

Hemiptera (Capsidæ).

HELOPELTIS THEIVORA. DEPREDATIONS.

(*p. 276*) would necessitate hibernation being in the condition of an egg deposited at the base of the Spring shoot—the portion that would be left in light pruning. Mr. E. E. Green informs me that in Ceylon the "eggs are very frequently deposited in the internodes between the bud-scale and the first leaf. It is this fact that allows so many of them to escape destruction in the ordinary course of plucking," That is a point worthy of careful investigation, but it would seem probable that ultimate hibernation may be in the condition suggested by Mr. Dudgeon.

Depredations.

Red Mosquito.

552. ***Appearance of Bushes with Red Mosquito.***—It would seem hardly necessary that I should attempt to detail the appearance of bushes blighted by mosquito after the very accurate account given by Mr Peal and several subsequent writers. In India the mosquito operates on the upper surface of the leaf, but, according to Dr. Aleyboom, the form met with in Java punctures the under surface. The insect both in its larval and mature condition inserts its proboscis through the epidermis of the leaf or shoot, and sucks the juice. A discoloration occurs over the area of depletion, and it becomes pale brown. A small speck may be seen in the centre of the spot, marking the actual puncture and the circumference of the space is indicated by a slightly darkened rim. In time this deepens in colour and dries up until it becomes a black and dead space of, perhaps, ⅛th to ¼th of an inch in diameter. If the puncturings are made by very young larvæ, they are said to be more numerous and to coalesce into irregular patches. The adult moves from place to place and may puncture the same leaf a dozen times, so that, on these spots becoming discoloured, the whole leaf turns black and shrivels up.

Discoloration of Leaves.

Adult and Larval Puncturings.

It is unfortunately the young shoots, the tea-making "two and a bud" or "three and a bud" portions, that the mosquito alone attacks, so that, when badly affected, the operations of a garden may be entirely interrupted and the bushes become black as if scorched by fire. The terminal buds being thus killed, the laterals spring forth and are in their turn punctured and killed, and for a time a rapid flushing occurs and a desperate effort made by the plant, without the planter being able to get more than a tithe of the shoots that he had anticipated.

Green Mosquito.

553. ***Action of Green Mosquito.***—That is briefly the story of the ravages of the red mosquito. It will best, perhaps, fulfil my

The Tea Mosquito.

purpose if I now give a passage from my diary, descriptive of the depredations of the green mosquito:—

TEA MOSQUITO: DEPREDATIONS.

As already explained, the larvæ are pale green, not red, and their manner of attacking the tea seems different from that of the insect met with on the South bank. The Patalipam insect first attacks all the lower lateral young buds which, when punctured, are killed. The leaves on the main shoot are also punctured, but not so profusely as with the red insect. The result of this is that the leaves remain on the shoot, become contorted and twisted, but still keep their green colour. The punctures become actual perforations through the tissue, not mere discolorations. Ultimately the main bud may be punctured, in which case the shoot stops growing. A bud right down at the redwood has accordingly to take its place, instead of the lateral buds which renew the completely killed and blackened central axis of the shoot, with the South bank insect. In other words, the mosquito of the South bank (which has red, not green, larvæ) attacks the main bud and the new leaves around it first, so that the flushing shoot becomes at once deflexed and turns black. When the terminal bud is punctured by the Patalipam insect, the whole shoot is killed and the pith will then be seen to be black within the still green shoot.

Lateral Buds First Killed.

554. ***Choice of Jats.***—Mr. Wood-Mason tells us that in his day the mosquito preferred the China plant, the indigenous enjoying "an almost complete immunity from attack." He goes into details in justification of this fact, by alluding to previously recorded instances where pests have shown favour for certain forms of a plant and have left alone others of the same species. Unfortunately this immunity of the indigenous plant cannot be said to continue to the present day. It is true, however, that mosquito very often commences operations in a garden, by attacking the China or hybrid bushes first, but it soon extends to the finer *jats* and may be said by mid season to take all kinds alike. It would almost seem, however, that certain tracts of country (such as the Tezpur District) that comprise a large percentage of comparatively new gardens or that have few, if any, gardens with low *jat* bushes, feel the effect of mosquito very much less than districts with many old gardens and a high percentage of inferior *jat* tea plants. As showing the extent to which the opinion still prevails that the indigenous *jats* escape the blight, I may

Choice of Jats. China Plant.

Inferior Hybrids.

Rhynchota (Capsidæ).

HELOPELTIS THEIVORA: REMEDY.

quote the following passage from a letter received by me from Mr. P. J. Macdonald: "Gardens of entirely Indigenous Tea are never attacked by blight." That may be the Cachar experience, but it is certainly not the Assam.

Remedy.

Physical Influences. *Conf. with paras. 521-2.*

555. ***Physical and Geographical Conditions.***—It has by no means been shown that position, soil, climate, shade, ventilation, methods of cultivation, and surrounding jungle do not exercise singly or collectively an influence on the appearance and distribution of this pest. These and other such topics have been spasmodically discussed in a perfunctory manner without any attempt having been made to tabulate results and conditions with a view to arriving at definite conclusions. This unsatisfactory state of affairs may in a measure have arisen from the early notion that "Blight" was a mysterious visitation due very possibly to influences for the most part beyond control. Prominence was thereby given to considerations such as I have named, to the exclusion of the actual cause, namely, that it was an insect, the germs of which had to be introduced, but could not be created by conditions of soil, climate, etc.

Distribution.

Local Circumstances.

556. ***Appearance and Disappearance.***—We now know the immediate cause, beyond all question, but, it seems to me, that greater attention must be paid in the future to the external influences named above before we can hope to approach the question of the eradication of mosquito. The appearance of the insect in one garden, its disappearance from another, only a mile or two distant, and its reappearance in a third, are local circumstances that possibly may be accounted for by external influences that favour the growth of the insect in the one, and are inimical to it in the other. So again there are conditions of a more general and widespread character, such as the gradual disappearances of the pest in the lower portions of the Assam Valley that call for solution. It is prevalent here and there all through the gardens of the South bank, *viz.*, in Dibrugarh and Sibsagar down to about Nigiriting, where it becomes almost unknown, it disappears very nearly from the gardens of Nowgong, though it reappears again at Silghat. So in the same way with the North bank, one garden here and another there suffers badly from North Lakhimpur down to about Biswanath and Tezpur, may be said to be quite free from the pest. Where mosquito abounds red rust is practically unknown.

Provincial Circumstances.

See Distribution of Red Rust. *Conf. with para. 852.*

The Tea Mosquito.

These cannot surely be accidental circumstances; they are more likely to be governed by conditions on the one hand favourable, and on the other unfavourable, to the life of the insect. To be able to contest the ground held by this terrible pest, therefore, we must fully understand such influences and steps should be taken to obtain something more than personal opinions and speculations. I would, therefore, urge on the Tea Association and all those interested in Tea cultivation the desirability of an annual census being taken for, say, the next five years all over the tea area. **TEA MOSQUITO: REMEDY.** **Annual Census of Position of Mosquito.**

557. As an appendix to this chapter (*pp. 297-301*), I shall suggest some of the more important questions that might be addressed to managers of gardens in tabulating returns for the census, and shall also propose a few experiments of a preliminary nature that might be instituted. Were replies to these to be furnished I feel certain that we should very soon find ourselves making a tangible advance towards the object finally desired, namely, the eradication of the pest.

558. ***The Collection of Mosquitos.***—At present the system pursued is to put on all hands to collect the insects and to have these destroyed. Some good no doubt is accomplished, but at most this is but a palliative treatment. When it is recollected that a garden of 500 acres may contain 1,500,000 bushes, and that when badly affected, each bush may have an average of 10 or more mosquitos, some conception is obtained of the very small results likely to be secured by a collection of even 50,000 daily. Still, however, each female destroyed might have meant eight to ten eggs deposited on the plant, consequently the system of sending out the women and children to collect, cannot be regarded as a useless expenditure. But to be of direct value the collection should be energetically prosecuted on the first appearance of the pest. **Collection of Mosquitos.** *Conf. with para. 598.*

559. ***Insecticides.***—I have already expressed my opinion on this subject. There are many poisons that no doubt would kill the larvæ of mosquito if they could be applied satisfactorily. To a large extent, however, the objection to the use of insecticides, in tea planting, is more one of expediency than utility. The adult insect flies off with the slightest disturbance: the larvæ move to the under sides of the leaves or into protecting corners and angles of the branches. It is commonly said they drop to the ground, but I failed to discover this being the case. On the assumption that they do **Insecticides.** *Conf. with paras. 381, 489, 592.* **A Matter of Expediency.** *Conf. with para. 91.* **Larvæ Drop to the Ground.**

HELOPELTIS THEIVORA: REMEDY.

drop to the ground, a system of tarring the stems, with a view to prevent their again crawling up, was recommended, tried, and, I believe, found unavailing as a remedial measure.

Influences of Rain.

The rain which falls almost daily at the season when this pest prevails, would wash off and thus prevent insecticides from remaining on the bushes, so as to kill the insects on their returning to feed. I have had very little experience, however, in the use of insecticides, and require to possess authentic results of comparative plots, before I could recommend that the idea should either be abandoned or large sums of money expended in this direction. But let me add, in conclusion, no insecticide should be employed that contains arsenic or any other highly poisonous substance, both because of the danger to the coolies and the risk that would undoubtedly be run in the tea bushes being killed, as well as their pests.

Arsenical Insecticides should not be Used.

Hard Plucking.

560. ***Hard Plucking as a Remedy.***—It will be seen that Mr. Wood-Mason entertained some expectations that his discovery of the location of the egg on the tea bush, might have practical results. (*Paras. 537, 543-5, 551.*) Unfortunately the insect deposits, perhaps, more eggs below the plucking point than above. It also lays its eggs on the green shoots left after the plucking has been made, so that heavy plucking can hardly be regarded as a direct cure. There would, however, be no object in leaving shoots fit for plucking or nearly so, on the bushes of a mosquito-infested plot of land. Plucking allows of tea being made, and at the same time removes the food of the insect, while it no doubt destroys a certain proportion of the eggs. Heavy plucking must, therefore, be beneficial, but to be effectual the plucking would have to be followed by light pruning, so as to cut off all the shoots down to the red wood, the portions so removed being carried off and burned. This no doubt would throw the flushing back very greatly, but if a complete check could be simultaneously given all over the garden, the removal of the food of the insect would no doubt help very greatly towards the eradication of the pest. What good is there in the flushing of a garden badly affected with mosquito? Practically no return can be obtained for months, and the loss may just as well be produced as a remedial measure as allowed to be brought about by the pest.

Not Effectual.

Is Distinctly Beneficial.

Is Desirable.

Effect of Pruning.

561. ***Destruction of Prunings.***—So far as I was enabled to ascertain, there would seem reason to think badly affected plots of tea (that perhaps should only have had a light pruning in the winter),

were they to be heavy pruned and the prunings burned, a check might be given to a return of the pest. But please observe this recommendation rests alone on the assumption that the insect hibernates on the bush and on the youngish wood. We possess no precise evidence in support of heavy pruning and the destruction of the prunings, as steps towards the mitigation of the pest; they can only, therefore, be recommended as doing little harm and possibly much good. Mr. Ilbert, of Moran in Sibsagar, writes me, "The part most affected is where I had interlined the old tea, and now old and young tea are attacked indiscriminately. I should think the proportion of young bugs to fully developed, would be about 150 to 1, which confirms what I told you that the young only appear in large quantities at the beginning of the year, and it looks as if eggs had been hatched on the tea bushes. The part of the garden which was very badly attacked last year, and which I pruned heavily, has not been touched by the mosquito as yet; where it is most prevalent is on light pruned tea. There is a very little shade in that part of the garden, and there is no jungle near." But, as opposed to the natural inference from such observation, I would mention that Mr. Alexander informed me "he had noticed that gardens that went in for heavy cleaning out, *i.e.*, removing after pruning of all twigs, leaves, etc., from the plants, were more affected the following year with blight than were gardens where that system had not been pursued." This, if general observations be admissible, might be accounted for by the supposition that, treated in the manner indicated, and having no old leaves, shoots, etc., the plants exposed their vital parts to the pest. Moreover, the new leaves and shoots being all killed and the plants having no old leaves, by which to breathe, they would naturally feel the shock of the pest very acutely. But Mr. Alexander's observation would almost point to the insect being an invader, and not one that hibernated on the tea.

TEA MOSQUITO: REMEDY.

Effect of Pruning.

Proportion of Larvæ to Mature Insects. *Conf. with para. 573.*

Effect of Heavy Pruning.

Does the Insect Hibernate on the Tea?

562. ***Firing Estates as a Remedy.***—It will be seen that one of the writers on mosquito, whose opinions have been reviewed above (Mr. Dudgeon) suspects that hibernation may take place in the ground (*see para. 547*). In the extracts from my diary (given below, p. 294), particulars will be found of a garden in which the owner, after trying every measure that could be suggested, to check the wholesale destruction that was being effected by mosquito, decided in 1886 to fire the entire plot. The bushes recovered the shock rapidly, the garden was

Fire as Cure.

HELOPELTIS THEIVORA: REMEDY.

improved, rather than injured, the pest was entirely eradicated and, what is more significant, up to 1895, the date of my visit to the garden, it had not returned. The cure thus seemed complete.

Mr. Crole may be spoken of as an over enthusiastic advocate for fire as a cure for mosquito. In his Tea Text-Book he says, "All that can be done to combat it is to burn down, root and branch, on its first appearance, all bushes at all affected by it."

Fires to Attract and Destroy Mosquitos.

At one time it was thought the mosquito might be attracted to light and thereby killed. With that purpose fires were kindled and kept burning at night. This proved a failure, and naturally so since most of the insects of this Order are but little attracted by light. Another experiment tried and abandoned was to carry flaming torches and to insert these here and there within the bushes, not long enough to set fire to the plants, but sufficient time to burn the mosquitos. This also was abandoned almost as soon as proposed, as it was found to do very little good, and was both troublesome and expensive.

Flaming Torches.

Lime as a Remedial Agent.

563. ***Liming the Surface.***—But assuming that the resting or hibernating stage, is deposited in the ground, it might be suggested that a liberal top dressing with lime, worked into the soil in the dry state, might have a beneficial result. I should like to see a plot of tea badly affected by mosquito treated as follows:—

(*a*) Heavy prune and burn the prunings immediately.

(*b*) White-wash every twig and stem completely, immediately after the pruning.

(*c*) Top dress the surface soil with dry lime and light hoe into the soil at once.

It would seem that if the hibernation takes place on the bushes or in the soil, a treatment of that kind would go a long way toward eradication, while at the same time it would vastly improve the health of the stock and the condition of the soil. Hardly any tea land in Assam could be said to have enough lime for the necessities of tea, and certainly no tea soils have already too much lime, so that the treatment recommended would be useful, even if not effectual, as a cure for mosquito.

Lime. *Conf. with paras. 285, 289-91 and 293.*

Selection of Stock.

564. ***Selection of Stock.***—In Chapter IV I have already suggested that the remedy for this, as also other pests, may have to be approached by the study of the protection given through certain races of the plant being found to be proof against the pest. It may have been observed

TEA MOSQUITO: REMEDY.

from the historic review above, that in 1881 when Mr. Wood-Mason visited Cachar, the indigenous plant enjoyed an almost complete immunity from mosquito. Since then, however, cultivation has either changed the plant in the direction desired by the mosquito, or the mosquito itself has changed, so that it no longer objects to the flavour of the indigenous tea. Mr. Steele, Manager of Shakomato Tea Company, in a communication I have had the pleasure to receive, has suggested that "we should work not so much to destroy the individual mosquitos as to prevent their appearance by some such means as manuring and changes in cultivation. It is necessary to find out what particular element in the tea sap is liked by the mosquito, and to endeavour to eradicate or adulterate that without prejudice to the character of the tea."

Preference for Certain Bushes.

565. I need hardly dwell on this subject further. It is by no means an unusual occurrence to find here and there bushes not attacked by the mosquito, while all the others around are black and every shoot killed. Surely the selection of a mosquito-proof stock would be by no means impossible. So again, such instances, as narrated, in conversation, by Mr. Peal, (*p. 291*) are not unusual, *viz.*, of certain bushes attacked year after year, when the rest of the garden has escaped the pest, or practically escaped. Examples of that nature point very possibly to a class of bush that should be eradicated as early as possible.

The subject of a more careful selection of stock is one with immense potentialities.

Natural Enemies of the Mosquito. *Conf. with paras. 522, 542.*

566. ***Encouragement of the Natural Enemies of the Mosquito.***—I have incidentally alluded above to Mr. W. L. Distant's discovery of a Reduviid insect which, he thought, might be parasitic on the mosquito, and which he had found mixed up with some samples of mosquito sent him from Ceylon.

Reduviid. *Conf. with para. 524.*

During my explorations in Assam I came across a Reduviid which was undoubtedly parasitic on the mosquito of the South bank. This is an insect, perhaps, half as large again as the male mosquito, has its legs mottled orange and brown, also very hairy. The thorax is of a brown tint, and the abdomen orange coloured. It is thus remarkably like the mosquito, only a little larger and stouter built, but may instantly be distinguished by its *not possessing the drumstick-like spine on its back* so characteristic of the mosquito.

Hemiptera (Capsidæ).

HELOPELTIS THEIVORA: REMEDY.

567. I watched this insect capturing the mosquitos and transfixing them with its powerful proboscis. It is, I have no doubt, the natural enemy of the mosquito and the planters' greatest friend. If the collections brought in by the children are carefully examined, there will be no difficulty in picking out a few of this insect, for they are, I fear, regularly gathered from the idea that they are mosquitos. Once seen they may be readily enough recognized, even by the children.

Production Artificially.

568. I would suggest that the greatest care be expended on the encouragement and the multiplication of this insect. A few might be placed in a cage, consisting of a tub with growing tea bush enclosed by mosquito-curtain cloth and live mosquitos daily given them to eat. If the children employed to catch mosquitos, were made to feed these insects with live mosquito, they would soon be recognized, and their destruction discontinued. At the same time the life history of the Reduviid should be studied, with a view to discovering a method of artificially increasing their number, by breeding them in captivity and liberating large swarms on the estate.

Most Hopeful of all Remedies.

569. I am more hopeful of this little parasite than of any of the other remedial measures alluded to above. The collections at the Indian Museum have not sufficed to enable me to name it for the present; it is apparently an insect which has never before been collected. My specimens have been preserved in *Tube No. 89*.

Other Natural Enemies.

570. On visiting the North bank I enquired of Mr. Lindsay Alexander if he had discovered any insect feeding on the mosquito. He replied that he had, and accordingly sent out his collectors to find some for me. Two species of plant-bugs were brought in, one belonging to the genus **Melamphaus** (*Tube No. 123*), the other to **Sycanus** (*Tube No. 389*). The former is an insect about an inch in length and with a reddish body below, the other about three quarters of an inch in size and quite black. I had not the opportunity of witnessing these devouring the mosquito, but Mr. Alexander assured me that he had kept them in captivity and fed them daily with the mosquitos brought in by the children. Here then we have two more friendly bugs that should be studied and encouraged on every hand. But I should suspect that these species would prove less tractable than the smaller and more active Reduviid above alluded to. I was considerably surprised to find that that parasite, found fairly plentiful in the mosquito-infested gardens of the South bank, was unknown on

the North, and that its place was actually taken by the large species mentioned, which I had not previously seen in any of the gardens to the South.

TEA MOSQUITO: REMEDY.

Spiders. *Conf. with para. 549.*

There no doubt are other insects that prey upon the mosquito, besides those found by me. Mr. C. N. Harcourt, of Ging Factory, Darjeeling, tells us that a small spider had been noticed by him to attack it. The number of species of spider that might be collected in a Tea Garden would be very great and are all possibly friendly. But I never observed a species of spider to attack the mosquito or, indeed, any of the tea pests.

Ladybirds. *Conf. with paras. 531, 608, 614.*

571. So far as I could discover, none of the species of ladybird beetles are parasitic on the mosquito. My opportunities for study were, however, too unsatisfactory to justify my affirming that they do not live on the mosquito. Ladybirds have been found of so great value in other countries, and with agricultural pests generally, more especially with scale-insects, that it would be unwise to conclude that they are not likely to be found of value with the mosquito. I should, however, strongly urge that my discovery of a parasitic Reduviid receive the most careful consideration, as that insect seemed to me to give every prospect of its being of the greatest service to the tea-planting industry.

Parasitic Fungi. *Conf. wi para. 592.*

572. ***Parasitic Fungi as a Cure for Mosquito.***—In the introductory review of the historic facts that bear on the study of mosquito blight, I have alluded above to a suggestion made by Mr. J. Wood-Mason, namely, that an effort should be made to discover some parasitic fungus that might be employed in the eradication of mosquito. The idea is a most admirable one, and has recently made considerable progress in other countries and in connection with other industries. I commend it as worthy of the most careful enquiry. So far as my investigations went, however, I failed to find any mosquito or other insect that gave evidence of being parasitised. That, however, cannot be looked upon as in any way detracting from the value of the proposal. To bring about the result indicated would necessitate the formation of a laboratory for advanced microscopic research, and the discovery of the desired fungus might be protracted for years.

Diary Notes on Mosquito.

573. It may help to exhibit the distribution of this pest, and also to mainfest some of the opinions held by the planters regarding it, if I publish

Rhynchota (Capsidæ).

HELOPELTIS THEIVORA.

here a few passages taken from my daily observations made during my rapid tour through Assam :—

" During a visit to Cherideo, Sibsagar District (20th March), an important observation may be said to have been made, namely, the fact of no young mosquitos having been seen, nor any eggs though carefully looked for. This would seem to point to the inference that the first batch may germinate from eggs deposited on some other plant than the tea, that they mature there and fly to the tea subsequently. If this be so, then later on, as the pest increases, eggs and larvæ should be both found on the tea. The lesson from this would seem to be to keep jungle down and at a distance, to pluck hard all affected bushes early in the season, and even to again prune and destroy the prunings so as to check the germination of the eggs deposited on the tea. (*Tube No. 164.*)

Adult Insects First seen. *Conf. with para. 561.*

" On the 6th April I had a conversation with———, Superintendent of———, in the Sibsagar District, on the subject of mosquito blight. As it may very possibly be found of interest, the chief ideas may be given here in the form of question and answer :—

Adult Insects First seen.

1. Do mature or immature insects appear first? Mature.

2. When do they appear? May or June, though one or two may be seen earlier.

3. When do they leave? End of November.

4. Do they appear on any particular side of the garden? Round the sides near jungle.

5. By eradicating the surrounding jungle to a considerable distance and pruning the tea freely, badly affected bushes are got under to a large extent.

Thinks it does not Hibernate on the Tea.

6. Do you believe the insect hibernates on the tea? I cannot say, but think not, for the reason that after November and during pruning it is rarely, if ever, seen.

7. What sort of soil, would you say, is the prevailing feature of the estate? Black sandy loam with red clay underneath? Possibly forest, not jungle soil.

On the 8th April I had a conversation with Mr. L. G. Ilbert, Manager of Moran in Sibsagar District, on the subject of Mosquito Blight. Following the plan adopted in the previous record, the substance may be here given in the form of question and answer :—

1. When do you get mosquito? June, when first seen; but not to the extent to injure the tea until August or September.

2. When do the insects disappear? Seen to cease feeding in October.

Spread from Lower Portions.

3. Where do they come from? They spread from the lower portions of the garden near *halluhs* in which the so-called wild **Cardamomum** grows.

4. Have you seen it feeding on any other plant but the tea? Never seen it on any jungle plant, but some years ago I planted **Hibiscus** near the garden, and it became badly affected, in fact the mosquito attacked both tea and **Hibiscus** alike.

I also think that it attacks the *Sau* tree (**Albizzia stipulata**).

Prevalent under Shade.

5. Does shade affect it? Yes, most prevalent under trees. **Ficus** and **Cedrela** seem to be its favourites, more especially the former. Indeed I think it may even be said to start under fig trees.

Immature Insects Appear First.

6. Have you observed whether the adult or the immature insects appear first? Immature, in largest quantities.

7. Have you found any method of eradication? Cutting down jungle and shade, pruning the affected parts severely, and burning the prunings. This is done at pruning season—November and December.

The Tea Mosquito.

At a garden visited on the 8th April (in the Moran Section of the Sibsagar District), I found the mosquito most prevalent in low land near the jungle. Although this garden has a large section under China plant, the mosquito showed a decided preference for the Assam indigenous. (*Specimens in Tube No. 6.*)

TEA MOSQUITO.

Preferred Assam Indigenous.

Mr. S. E. Peal, during a conversation I had the pleasure to have with him on the 9th April 1895, said that mosquito appeared first about 1867. Mr. Jenkins thought it was bad cultivation, others assigned various reasons. On being invited to narrate what led to his discovery of its action, he said that for several successive days he sat underneath a badly affected bush and watched until he saw the insects that punctured the leaves. Jenkins denied this discovery even then. Peal demonstrated it by putting fresh leaves in an empty kerosine oil tin along with a few insects—next morning the leaves were all punctured, this was satisfactory proof of a very important discovery. In this connection he remarked that it was curious that it should puncture the upper surface only, though it hides on the under, when disturbed.

Attacks the Upper Surface of Leaves.

He informed me that he first saw mosquito at Jeypur (Tingkong), an isolated garden separated by many miles from any other estate. Soon after the insect became general all over the greater part of the South bank.

On being questioned whether mature insects or the larvæ appeared first on the tea bushes, he replied that the early ones seen by him were all wingless and red. It was in fact a couple of years after he had proved that mosquito punctured the leaves before he identified the mature insect. On being pressed as to whether now-a-days the advent of this scourge was in the perfect or larval condition, he replied that he believed it was the latter, but that both conditions were, as a rule, established before their presence had been detected. He had never made experiments, during the early part of the season, to test the comparative abundance of one condition over the other.

Immature Insects Appear First.

Asked as to the colour of the Assam mosquito Mr. Peal said, he had never seen a green one, and did not believe they assumed that colour on having sucked the juice of the tea plant.

Colour of Assam Insect.

Conf. with paras. 517, 525, 529.

Speaking of the various efforts towards eradication Mr. Peal said, he had once assigned plots of the gardens to certain boys. It was their duty to keep their sections clean, and they were accordingly threatened that they would be punished for every mosquito found. The pest was in this manner exterminated in about a week.

Adverting to the enquiry as to the habitat of hibernation he said, that he had once marked down a bush on which he found mosquito recurring for four years consecutively, but they never seemed to extend to other bushes hard by. Accordingly *he thinks mosquito must hibernate on the tea itself.* He, however, admitted there was truth in my remark that the bush in question might have been a *jat* specially appreciated by mosquito, and one accordingly that should not be cultivated.

Preference Shown for Certain Bushes.

He further informed me that he had observed a stream of mosquito following a line, as it were, along the path of the wind. He said also that he had seen the blight on rejected tea, but not to his recollection on wild tea. Does not recollect his having said that mosquito punctured wild *pán*.* That remark was in consequence of my having said, that, though I had searched hard for *pán* leaves punctured or for mosquitos resting on the *pán*, I had failed utterly to confirm an observation which, I believed, he had made, namely, that it had been seen in the jungles puncturing the wild *pán*.

* See the passage quoted from a paper by Mr. Driver, page 277 above.

Hemiptera (Capsidæ).

HELOPELTIS THEIVORA.

Adult Insect First Observed.

During the inspection of Atkhel on the way to Amguri (18th and 19th April), I asked the superintendent about mosquito. He said that he had distinctly observed for two years that the adult black-winged insect first appeared, and that gradually the percentage of immature or red insects increased as the season advanced. (*Collections in Tube No. 229.*)

Method of Investigating Mosquito.

Visited Amguri on the 21st April. Mr. Buckingham very kindly arranged to have one or two tea plants growing in tubs and each enclosed by a light bamboo frame work covered with mosquito-curtain cloth. The cloth had been made in the form of a tube open at both ends. The lower end was securely fastened around the tub, and the top tied into a knot with a string, so that it could be opened as the door into the enclosure when so desired.

Shape and Size of Puncturings

On the afternoon of the 22nd April, some eight or ten live mosquitos, of various ages, were placed within one of the enclosures. Before being introduced, not a leaf showed any signs of mosquito blight, but in the morning every young leaf on the plant was covered with spots. There was no difference observable in the size or shape of these markings—that is to say, there was no distinction into the punctures that might be attributed to the young, as compared with the old insects within the enclosure. This observation, may perhaps be regarded as to some extent disposing of the statement made originally by Mr. Peal, and often since by others, that certain minute circular spots (like punctures) seen on tea bushes, had been made by the immature mosquito.

Experiment with Adhatoda as an Insecticide.

Syringed these insects in the forenoon with a preparation of **Adhatoda** of three hours' maceration. No result, the mosquitos though rendered stupid and inactive, were not killed.

Syringed at 9 A.M. 23rd, insects still not killed. It thus appeared that **Adhatoda** was useless for the purpose it had been recommended in connection with this insect, but of course the maceration might not have been properly prepared. Longer steeping might be necessary. As I was to be at Amguri for another day only, this experiment could not be repeated. But I tried preparing the insecticide by boiling, result the same. I then syringed certain other mosquitos with the cold infusion made rapidly, still the insects were not killed.

Coupling of Male and Female.

April 22nd made another enclosure with one-year old plant. Took pair of mosquitos (male and female) found in union. All the perforated or otherwise injured leaves were previously removed from the enclosed plant. The pair remained united for three hours, on separating they flew off to the young leaves and each commenced to puncture. April 23rd, two young leaves completely covered with spots. No change in colour of mosquito after having sucked the juice of the tea leaves. April 24th, three leaves completely covered with punctures, also young stems stained as if from punctures in depositing eggs. Was unable to complete the investigation as to period when the young larvæ would appear since I had to leave Amguri. In carrying the tubs with me the enclosures got destroyed, and the experiment was thus rendered useless.

No Change in Colour on Sucking the Sap.

In my second mosquito observation cage I had the surplus insects killed. Yesterday one pair of mosquitos united. It is presumed, therefore, that eggs may have been laid. If all mosquitos had been left, they would have killed the plant outright—hence their being removed. There were in all some twelve insects, but the immature ones did not seem to make much progress, nor the old ones to loose much of their activity during the four days' confinement. Twigs with brown patches on young shoots and nearly all the leaves punctured but no appearance of eggs. No change in colour of the mosquitos within the enclosure.

Experiments with Other Pests.

The Tea Mosquito.

TEA MOSQUITO.

In my third observation cage I introduced on the 25th April one of the sandwich caterpillars. In less than 24 hours it had united and partially eaten three leaves. Added also one caterpillar of **Dasychira mendosa**. In one day it had eaten several large holes in one leaf. It works on the under surface, and at night.

Added also two limpet caterpillars. They attached themselves at once to the leaves and each formed a large patch of spots in a couple of hours. They seem to cause a decomposition of the tissue of the leaf by the force of suction. A comparatively short time will suffice (say half an hour) to form a circular patch of killed and partly devoured tissue.

Having satisfied myself as to the peculiar action of these caterpillars, I had to remove them or they would have rapidly killed my tea bushes.

To Solve the Life History of Mosquito.

I have mentioned these circumstances of imperfect experiments in order to demonstrate the ease with which most of the obscure features in the life of the mosquito might be solved. At present it is not known how long the individual lives; what time is spent in the condition of egg; the duration of the larval state, the number of generations that take place a year, nor the still more important point whether or not the insect hibernates on the tea bush. Any planter who would take the trouble to have half a dozen two-year old plants placed in tubs and enclosed either with cloth or fine wire gauze might make the necessarily daily observations required to solve these and all the other obscure points in the life of this insect without either any appreciable expense or trouble. I had to change my abode almost daily, and it became, therefore, an impossible task to make observations on plants and insects that had been jolted along a dusty and hot road all day long. I tried my best, but failed, and I lagged about with me over Assam some half a dozen plants in tubs mainly with the object of demonstrating the simple nature of the appliances required to collect the scientific details so urgently necessary, before we can be said to be in a position to decide upon any definite mode of attacking the insect pests of the tea plant. (*Specimens preserved in Tube No. 237.*)

April 24th, visited a garden in Jorhat Division. Mosquito rare.

At a garden visited by me on the 25th April in the Jorhat Division, I found no mosquito.

At Jorhat, on the 26th April mosquito was said to be rare.

At Badulipar (May 2nd) I found no mosquito, though unpruned tea existed.

On reaching Dibrugarh District I visited first of all the gardens within an easy radius around the saddar station. I went and spent the day (15th June) with Mr. M. He informed me that he had arrived at the opinion that **Adhatoda** did not kill mosquito, but that it stupefied it so that it could be easily caught.

Firing Badly affected Estates. *Conf. with p. 286.*

At Panitola I was told of several causes where gardens badly infested with mosquito had been set fire to, with the result that, when the trees sprouted the mosquito never returned.

At Makum, on the 21st June I found mosquito on one or two leaves.

At Tingri visited on the 26th June, mosquito was occasionally seen.

Mr. J. Alston and Mr. Walker were good enough to take me over Sukerating on June 30th. While doing so, they gave me a most interesting

Rhynchota (Capsidæ).

HELOPELTIS THEIVORA.

account of the serious visitation of mosquito that garden had sustained, and the method adopted for the eradication of the pest. As I am permitted to publish the information, I shall endeavour to relate the subject of our conversation and the facts given to me. In 1886 mosquito appeared towards the end of the season, 4,000 maunds of tea had been made that year. In 1887 the pest spread all over the 450 acres and the yield fell to 1,600 maunds.

In November and December of that year the entire garden was severely pruned and also trenched, and about half green soil manured, the prunings were burned on the soil along with bamboo and other dry materials brought from the jungles for that purpose. It was set fire to on the wind side, and it burned for several days. The bushes were thus scorched and about 1 per cent. killed. The whole garden became black, and looked as if entirely killed; but new shoots sprang from the roots, and in a remarkably short time it had the appearance of a new garden. For about 20 feet all round the garden the jungle was cleared and also burned. Mosquito entirely disappeared and has never returned, and the garden has, moreover, been much improved. It sprouted late and was tipped only once or twice until it came regularly into bearing in July. That year (1888) it yielded 3,685 maunds.

Garden Recovered.

As seen at the present time (June 1895), the bushes may be described as branched from the ground and each has so many strong erect branches that they form a dense dome. It is said to yield 10 maunds an acre, but that includes a 100 acres of young tea recently opened out.

Appeared near Shade.

There was shade and bamboo clumps along the main road, and the mosquito appeared in that part of the garden first. During the plague of mosquito all the young mango bushes in the bungalow garden were also punctured and the twigs killed. The insects were seen by three independent persons puncturing, and the red immature insects were also found and collected from the mango trees. Mosquitos were observed in the jungles on a **Solanum** (*Bengan kata*) or wild brinjal. **Mæsa indica** is prevalent outside the garden, and the leaves are punctured, but the mosquito on that plant was recognized as a different species from that which attacks the tea.

Mosquito Reported on Mango.

The story of the mangoes being seen to be punctured by the true tea mosquito interested me greatly, and I at once made for the fruit garden in order to see if any mosquitos could be found on them now. All the young leaves were undoubtedly spotted as if punctured, but no trace of mosquito could be found. Moreover, the centre of each spot, or supposed puncturing, was seen to bear a fungoid growth which never happens on the mosquito puncturing of the tea. I was thus sceptical of the story of the true mosquito on the mango. And I may add to the above extract from my diary that I have since, all over Assam and Northern Bengal, found the young brownish-green delicate leaves of the mango spotted in the way mentioned above, and think it likely that mosquito may have been seen resting on the mangoes, and that fact, coupled with the spotting of the young leaves, was probably taken as proof that they punctured and sucked the sap of the mango as well as the tea plant. Planters would, however, do well to keep a close watch on their avenues of mangoes since my observations by no means prove that the above report was inaccurate.

I visited Patalipam (North bank) on July 6th in company with the Superintendent Mr. J. Lindsay Alexander, who had most kindly come to Dibrugarh to meet me and to convey me in the Company's steam-launch to Patalipam.

The Tea Mosquito.

The garden consists of a rich sandy loam, so much so that earth will not adhere to the seedlings on being transplanted. It is, however, a garden very badly attacked by mosquito—a fact opposed to the idea advanced some years ago that that pest did not prevail near running water. Patalipam is on the banks of the Subensari river.

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Presence of Running Water.

On going into the garden I at once observed one thing very peculiar about the mosquito found here. The effect of its puncturing was quite different from that observed elsewhere. I was immediately struck with this, and refused to believe that it was mosquito, upon which my companion smilingly said, there would unfortunately be little difficulty in convincing me of that fact. In a few minutes his coolies had captured a hundred or so of the insects in all stages. ***But they were all green in colour even down to the most minute larvæ.*** The adult males were almost uniformly black with a tinge of green, and the females pale green shaded into darker tinges, the belly being almost white. They were devoid entirely of the orange-yellow colour on the pronotum, the body was not yellow, nor was it found to possess the black bands over the back of the anal extremity. The insect was also observed to be considerably smaller than the brilliantly coloured mosquito seen on the South bank.

Green Coloured Mosquitos.

I had the *Indian Museum Notes* with me at the time of examination of the live insects, and compared the drawings and descriptions with a large number of this mosquito in all stages of its growth, also with my preserved specimens of the South bank mosquito. I am aware that it has been affirmed that the green colour, often recorded prior to this, is due to the insects sucking the sap of the tea leaf. On this point, for example, Mr. E. T. Atkinson (*Indian Museum Notes, Vol. I., page 180*) says of the larvæ "colour amber-hyaline, but after sucking the juices of the green leaf for some time it becomes of a greenish colour." If that be so, then during my entire residence on the South bank, the mosquito must never have been feeding for, though I looked into this point with the utmost care, I never saw one that had the very slightest greenish tinge. Moreover, I reared the mosquitos within specially prepared houses for that purpose. I watched the red larvæ as well as the perfect insects puncturing and sucking the juices of my tea bushes, until the bushes were almost killed, without witnessing the slightest change in the colour of the insects. I simply cannot credit this story of change of colour.

Green Colour said to be due to Sucking Tea Sap.

Conf. with paras. 517, 585.

The mosquito of the South bank, when scarcely larger than the point of a pin, is almost bright scarlet, and, as it gets older, becomes orange, then, as the wings form, it turns into a dirty greyish pink, and finally with the perfect wings assumes the adult condition. I must have received thousands upon thousands of samples for, wherever I went, I had the day's collection made by the coolies brought to me for examination. I, moreover, preserved some seven or eight bottle-fulls of these insects in all their stages, but I never saw a green one. I had intended to draw attention in my report to this mistake regarding the green colour, and, therefore, I was naturally surprised when I reached a garden where the mosquitos were green at every stage of their existence. This was all the more surprising to me when I found this peculiarity associated with a distinctly different mode of puncturing the leaf. Though not an entomologist, I am accordingly satisfied that the insect to which I allude is a distinct species. I expressed that opinion to Mr. Alexander, and he at once replied, "I quite agree with you and, moreover, we possess both species. The red form is extremely rare, but I think I may be able to get you a few." His collectors were accordingly despatched on that quest, and, sure enough, brought some of the characteristic form of **Helopeltis theivora** though only in the adult condition.

Red Mosquito.

A Distinct Species.

Hemiptera (Capsidæ).

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I must, therefore, leave future investigators to confirm my observations, and give a new name to the green **Helopeltis** or to exhibit the mistakes I may have made in the study of the North bank insect as compared with that on the South.

Since writing the above note in my diary, I have been told that the green insect is occasionally found in some gardens on the South bank, so that it is probable they may be both equally widely distributed. But whether separate species, varieties or only different conditions in the life of one and the same species, the red form is that characteristic of the South bank, and the green that met with on the North bank of the Brahmaputra.

Prefers the Hybrid Bushes.

But to continue the story of the North bank insect. I may say that during my visit to North Lakhimpur Mr. Alexander informed me that in his experience this insect prefers the hybrid to any other teas. In Patalipam it usually appears about July, and continues till the end of November. But in Dirpai it is present throughout the year. Dirpai is a small garden of 150 acres extending in a long band from the Subensari river into the forests due east. The part most affected is the northern half.

Experiment to prove hibernation.

Mr. J. Lindsay Alexander informed me that he tried an experiment to prove whether the mosquito hibernated on the tea or in the ground around the bushes. He had a bush completely encased down to the ground with very fine wire gauze. He placed inside a good few live mosquitos. The leaves were all punctured, and continued so till the end of the season. He left the covering without interfering with it in the slightest until the bushes all around were next year badly affected. He then removed the cover. Not a leaf was punctured and the bush showed a bright green colour that for a few days contrasted strongly with the others. But being left exposed it was soon again blighted. He accordingly inferred that the insect does not hibernate on the tea, nor in the ground around the bush.

Causes of Possible Error.

This, as I explained to Mr. Alexander, was an experiment of the right kind, but by itself it could prove little or nothing. Had it been repeated once or twice, and not with one bush but with several, it might then no doubt justify the inference he had drawn. The confined condition of the bush might, however, be unfavourable to the life of the insect. The larvæ might have made their escape. It may have been opened too soon. May not have gone far enough below ground. One such experiment for many reasons might very possibly be misleading. But I added that, so far as I heard, this was the only instance of an experiment to trace out the life history of this destructive pest having been made by a planter. Doubtless many more such experiments have been made and not communicated to me. It would not in fact reflect much credit on a body of able and enlightened men who possess every facility and opportunity necessary for the solution of the obscure points regarding this their most serious pests, if it could be said that for the 20 years of its ravages they had not put forth the slightest effort to assist themselves. I shall be glad, therefore, if these remarks call forth the nature and results of all other such experiments that may have been performed.

Adhatoda as an Insecticide.

The results of experiments with **Adhatoda**, as an insecticide against Mosquito, I was told, had been contradictory. In one garden it was found useful, in another not.

Green Mosquito.

At Gopesadarhu, Charali, visited on the 12th July, the Mosquito met with was found to be the green form. As a rule, it comes in July and stays till December. If "forcing weather" occurs the plants are able to throw it off. (*Tube No. 126.*)

Mijika Jan, Charali, 13th and 14th July 1895, Mr. G. H. Swinley informed me that, long continued damp weather and no sun, say in

September, brings out mosquito until the garden in some years is next to useless. It is the form with green larvæ.

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Red Mosquito on China Plants.

On the 16th July I went out through Koliabar with the Manager Mr. Wood. Some parts of the garden are low undulating valleys, but the better parts are upland flats of rich red clay. The tea is mostly poor *jat* planted too far apart. If interlined the outturn might, I should think, be vastly increased. In point of rainfall there is a vast difference between the gardens above the Nowgong hills (Sibsagar and Golaghat) as compared with those below. In Koliabar mosquito is often bad on poor *jats*, but the red kind is met with.

First Appearance in Cachar.

At Kaliden visited 16th July, I was informed mosquito was unknown though present in Koliabar, only 13 miles distant. The Manager Mr. N. Barry told me he first saw mosquito in Cachar. He believes it was first recorded about 1864 and at Bura Jalinga. The following year it was noticed on the *ping* tree—a tree something like a mango with smaller and darker leaves. The insect was actually collected from the tree, and its method of puncturing studied.

Mosquito Unknown.

At Salonah, Nowgong, visited 17th July, Mr. Henderson informed me that mosquito had never been known in that neighbourhood.

Mosquito has not as yet visited Solal, but I found a very few leaves punctured with it at Seconee (July 18th, 1895).

On 20th July I visited Nahor rani, of Tezpur District, a garden that has much new tea of Assam *jats*. Near the bungalow on left-hand side of main road I found a good many leaves punctured by what I took to be mosquito, but failed to find the insect. The leaves seemed to be punctured in the manner ascribed by me to the Sibsagar insect.

APPENDIX TO CHAPTER ON MOSQUITO BLIGHT.

(*Conf. with para. 557.*)

FUTURE ENQUIRY.

574. I would suggest that future enquiry into the subject of this pest might be framed on the lines indicated by the following, among other, subjects :—

1. Location and Condition of Garden :—

Points Regarding which Information is desired.

(*a*) Geographical, *viz.*, district and sub-division in which situated.

(*b*) Physical features of garden, *e.g.*, level, hilly, grass land, or forest clearance, as the case may be.

(*c*) Nearest river and direction from the river, *e.g.*, ... miles east or north, etc.

(*d*) Position of jungle, *e.g.*, surrounded and the nearest other garden being . . . . miles to north, south, etc.: or jungle lies on the north side: jungle kept well back, nothing to speak of nearer than . . . . miles: surrounded by grass land: practically surrounded by other tea estates and nearest tea garden lies to . . . . by . . . . miles.

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(*e*) Relation to rice cultivation, *e.g.*, approximate height above the rice annual inundation; distance of rice cultivation from the tea estate.

(*f*) *Hullahs, e.g.*, depressions with connecting *nullahs:* their position within the garden: condition, annually cleaned out and water given free passage, or filled with jungle and water more or less stagnant.

(*g*) Nature of soil, *i.e.*, sandy loam, red-clayey loam, black-clayey loam or rich black loam (rich in humus).

(*h*) Climate, *e.g.*, direction of prevailing winds: average annual rainfall: month of highest rainfall: approximate period of monsoons: average day temperature in the shade during March, June and October: month of highest, and month of lowest, temperature.

Cultivation.

2. ***Cultivation:—***

(*a*) Number of heavy and number of light hoeings a year.

(*b*) Number of weedings.

(*c*) Condition of drainage, *e.g.*, depth of trunk drain or canal: depth of main drains within the estate: depth of lateral feeding drains: distance apart of lateral drains: extent and nature of terrace cultivation.

(*d*) Season of pruning.

(*e*) What is done with the prunings?

(*f*) Plucking season: when does it commence? what date could be called mid-season? usual date of termination of plucking: nature of plucking, *viz.*, "two and a bud," "three and a bud," "two and a bud with portion of third leaf," etc., etc. When mosquito appears bad, state the extent of plucking then instituted, and its effect on the pest.

Peculiarities of the Insect.

3. ***The Mosquito:—***

(*a*) From the records of the garden (the recollection of the oldest *sirdars*) in what year did it first appear?

(*b*) Did it attack any particular portion of the estate first? if so state the position of that portion (in relation to the remainder, *e.g.*, an out-garden. . . . miles to the east or west as the case may be), to the main expanse of the estate: appeared on the portion of the garden nearest to the jungles, in other words, on the east or north, etc., of the estate.

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(*c*) In what month does it usually make its appearance, and in what month does it disappear?

(*d*) Does it appear at one point, and spread from there all over the garden, or simultaneously break out here and there at one and the same time? If the former, describe the position and peculiarities of the portion of the estate in which it usually makes its appearance.

(*e*) Does it show any special favour for certain *jats*, such as China hybrid, indigenous Assam, etc.? does it show any preference for unpruned tea, for light pruned tea, for collar-pruned tea, for seedlings, or for old plants?

(*f*) Have you any grounds for thinking it hibernates during the winter months on tea? if so, kindly state these as fully and freely as possible.

(*g*) Does the winged insect or immature wingless insect appear first? This, I am aware, is difficult to answer, since the insect may have been some weeks in the garden before its presence had been detected, but an approximate answer could be obtained by counting the relative proportion of mature and immature insects in the daily captures for the first month or so.

(*h*) Kindly preserve in a bottle the first day's collection of mosquito, using as a preservative fluid—a weak solution of spirits of wine or better still half water, half glycerine: then later on, when the pest might be said to be at its worst, preserve another day's collection in a similar bottle. Place on the bottle a label bearing date of collection and name of garden. Forward these to the agents along with your replies for each year to the above enquiries.

4. ***Experiments to test the Life History of the Insect:—*** Life History.

(*a*) Have half a dozen two or three-year old plants well rooted in separated tubs. Construct a bamboo frame work over these, and enclose it by mosquito-curtain cloth; tied tight around the tub and have it sewn completely all over the frame work. Fine wire gauze may be used if preferred. On one side of the net enclosure, sew a tube of the cloth about two feet long and sufficient to allow the arm to be inserted, the mouth of the tube being tied around the arm, so that none of the insects can escape.

Hemiptera (Jassidæ).

CHLORITA FLAVESCENS.

575. In connection with the subject of possible natural enemies to the mosquito, I may bring to mind a bug that may be said to occur here and there throughout the tea districts of Assam. It belongs to the genus **Pæcilocoris.** In November 1869 **Mr. Edgar**, of Cossipore Tea Estate, Cachar, sent what I take to be this species to the Agri.-Horticultural Society for determination, and **Mr. Moore** named it **Pæcilocoris hardwickii. Mr. Grote** in forwarding **Mr. Moore's** report said that, "this insect had been observed as infesting the tea plants of Assam many years back."

It is found in clusters of five to ten, low down underneath the shade of the bush. They are most inactive creatures and never seem to be doing anything. They are between half to three quarters of an inch in length and a little less in breadth. Are pale yellow coloured with curious finger-nail-shaped orange-red patches round the thin margin. The head is bright-metallic blue. The thorax scarlet, and behind the thorax there are three metallic blue patches, the centre one of the three forming the outline of a triangle. Along the back are three orange-red bands and right over the anal extremity other two metallic blue bands.

576. **Mr. Fleet** wrote me on the 22nd April that he placed these insects under observation and "could not find that they were injurious, or the contrary. The original ones that I first noticed on a bush, on the 30th ultimo, have not even moved from the leaves on which I found them." In a subsequent letter of the 28th May he again wrote that, "a second and winged generation of this bug is now to be seen on the bushes."

I took the liberty of sending samples of this bug to **Mr. Green** to obtain his opinion regarding it and to know if it had been seen on tea in Ceylon. The following may be given from his reply :—"This is apparently immature, and would eventually develop into one of the large PENTATOMID bugs. It belongs to a plant-sucking family ; but some of them are known to vary their diet by transfixing and sucking caterpillars. The habit of this large species should be watched. It may prove to be a friend."

Family JASSIDÆ.

67. (a) Chlorita flavescens, *Fabr.*

GREEN FLY.

GREEN FLY : STUNTED BLIGHT : CRINKLY BLIGHT.

References.—*Peal in Tea Cyclopædia, 37-38 ; Correspondence l. c.,*

GREEN FLY.

43-49 ; Journ. Agri.-Horti. Soc. Ind., Vol. VII., Proc., 25th June 1884, pp. xcv.-vi. ; Tea Planter's Vade Mecum, p. 104 ; Notes on Tea in Darjeeling, 49 ; Bamber in Annual Report, Indian Tea Association, 1893, p. 92 ; Bamber, Chem. and Agri. of Tea, pp. 248-251 ; Ind. Mus. Notes, Vol. II., 167 ; III. ; 9-12 ; (pt. 3), 140 ; IV., 42 ; Cotes, Insects and Mites, etc., pp. 34-36 ; Miles, Journ. Micro. Soc. Ind., Vol. V., p. 45 ; Crole, Tea Text-Book, pp. 83, 223.

(*Reg. No. 3.*)

577. History.—The first mention of this insect, as a tea pest, will be found in the Journal of the Agri.-Horticultural Society for 1884. On that occasion **Messrs. Begg, Dunlop & Co.** submitted, for opinion, samples furnished by their Manager of Kumber Tea Estate, Cachar. These were forwarded by the Society to the late **Mr. J. Wood-Mason** and were identified by him as a Homopterous insect closely allied to "the little Green-flies which are such a pest in the rains in Calcutta." He added that he had met with them frequently on tea bushes, but could never satisfy himself that they did any harm. The next writer on the subject was **Mr. S. E. Peal**, but unfortunately he assumed that it was a species of aphis, and called it accordingly "The Tea Aphis" —a name which crept into most subsequent books and reports. Having made that mistake he apparently assumed by analogy that it was destructive to tea and gave some startling details of the life of aphides, especially their parthenogenetic reproduction, as applicable to the green-fly. "When young," **Mr. Peal** wrote, "it can hardly be distinguished from a small tea bug (mosquito) either in habit or appearance, which might have been expected, seeing that they are closely allied forms." A writer in the *Darjeeling News* next announces the discovery of the insect in that district, and this is followed by the author of the little book called *Notes on Tea in Darjeeling*. **Mr. Bamber** published the results of some unsuccessful efforts to exterminate the insect with insecticides. In his work on the *Chemistry and Agriculture of Tea* he says that, in Assam it is known as "blister blight," and in Darjeeling as "green-fly blight." The mistake of confusing "stunted blight" with "blister blight" was followed by **Mr. Cotes** in the Museum Notes (*Vol. II., 167*), but was not repeated in his subsequent special work on the *Insects and Mites of the Tea Plant*. **Mr. Crole**, the most recent of writers on tea pests, repeats the old error of "green-fly or blister blight," while he gives a separate paragraph on "stunted flush." In this connection he remarks,

Appearance in Darjeeling.

Confusion in Names. *Conf. with para. 810.*

Hemiptera (Jassidæ).

CHLORITA FLAVESCENS.

Zigzag Stem.

It may be said to be most frequently seen (if not exclusively so) on heavily pruned tea. The shoots are stunted, swollen, succulent, very hairy, and the internodes (spaces between the leaves) deflected right and left in a zigzag fashion. But they are in no way discoloured, and there are no markings or puncturings of any kind. As they advance in age, the leaves rise on end (or stand in a vertical attitude), and become curiously closed up, face to face as it were, along the upper surface, while the midrib in time becomes curled backwards or even twisted spirally, to a slight extent. The texture of the leaves, when these changes have taken place, is also hard, so that they are unfit for tea-making unless plucked early. The buds are also arrested in their growth, so that the bush may be described as *banjhi*.

Crinkly Blight.

582. So far as I could make out, "stunt" is the first stage of this disease, and "crinkly blight" its ultimate development. On old bushes crinkly-blight sometimes occurs by itself, or a state of affairs of a very closely allied nature is produced when the plants are either suffering from insufficient nourishment or defective drainage. The leaves rise up to the vertical position and close up lengthwise, become hard and crinkly without any evidence of stunt or green-fly. The condition of stunt, so far as my experience goes, is exclusively met with on the shoots that spring from heavy or collar pruning.

Experiments to Test the Action.

583. Green-fly is undoubtedly very often found on both stunt-blight and crinkly-blight, but no one has as yet proved that it is the cause of these diseased conditions. I had a large number of these flies under observation within a cage over a live tea bush, but, though I watched them for hours together, I neither saw them puncturing the shoots nor eating the leaves. During the entire period of my investigations, the bushes showed no signs of stunting or crinkling. Similar experiments were performed by Mr. A. T. Wright at Noakachari with a like result. But neither of these experiments were carried out for a sufficiently long period to justify any definite conclusions being formed. They by no means prove that the popular notions regarding this insect are mistaken. But in support of the suspicion of a mistake, it may be useful if I give here a few passages from my diary.

584. According to Mr. S. E. Peal (conversation on the 9th April), green-fly does all the good in the world. It makes the bushes branch, and, if good weather follows, a heavy flush will ensue.

Green Fly or Stunted Blight.

585. The green-fly first appeared to his recollection about 1874 and at Golaghat. It came slowly up the valley and then turned west. It has never been so bad as it was on its first appearance. It took about two years to exhaust its severity. The enemies of the so-called green-fly, he added, seem to have developed and kept it in check for many years past until, as stated, it can hardly now be regarded as a pest. **GREEN FLY.**

586. At Badulipar (May 2nd) I thought I observed the green-fly eating the top surface of the tea leaf. Up to this date, though I had watched carefully for hours, I never observed the proboscis inserted into the tissue of the leaf—and even at Badulipar all I could say was that the insects seemed more in earnest at doing something than I had previously observed.

587. At Dibrugarh, on the 15th June I found the green-fly not very bad, though numerous branches were shown to me as stunted by it. These bore no indication of having been punctured or eaten—they were stunted in growth, and that was all that could be said.

Green-fly had so far only appeared to a slight extent in Dibrugarh this year: it was bad last. Is generally known as "stunted growth." But when discussing the matter with a planter, he seemed doubtful as to the insect having caused the stunting of which so much had been made by planters. He had seen the insects abundant without any stunting of the bushes.

588. At a garden in the Dibrugarh District, visited on June 27th, I saw a good deal of "stunted flush" with green-fly certainly abundant at the same time. On discussing this subject with a large number of planters who met together that evening, I found many were distinctly of opinion that green-fly often was to be seen on tea without the stunted growth being produced. There is certainly one observation in favour of the heresy of being doubtful of green-fly effecting what is very generally attributed to it, namely, that stunted twigs and leaves show no indication of being punctured or eaten. It was too late in the season to find my little pink-mite, but I may add that, had I been asked for the cause of interrupted growth without having been taken to the plot in question in order to be shown green-fly, I should very possibly have pronounced the bushes as having suffered from the ravages of the pink-mite. **Stunted Parts give no Indication of being Punctured.**

589. Mr. Lindsay Alexander informed me that in his experience green-fly appears in Patalipam generally about May; it attacks the flush that follows the plucking of April. He told me that he believes the insect eats the skin from the veins of the leaves, thus causing them to turn pinkish, this then checks the circulation of the sap, and thus stunts the growth. When the rain falls, the leaves curl. This is sometimes known as the "crinkling blight" or "stunted blight," but the peculiarities that give origin to these conditions do not show till about the end of May. When this occurs, the twigs become very thick, and the axis bent zigzag between the numerous buds giving the main branch **Eats the Epidermis of the Leaves.**

Conf. with Pink-Mite, para. 780.

Rhynchota (Jassidæ).

CHLORITA FLAVESCENS

the appearance of a broom. It begins to disappear through the elongation of the branches which takes place about the end of June when the rains may be said to have been fairly established.

Heavy pruned tea is most liable to this blight, and the injury is more severe and lasts longer on that condition than on ordinary tea. Although the effects only show up about May, the insect is present from a much earlier date, and may even be very abundant though the bad effects do not appear for some time.

Adhatoda was tried with good results at Dirpai.

Doubts Green-Fly Causing Stunt.

590. Gopesadarhu, Charali, visited on the 12th July. Had an interesting conversation with Mr. W. A. Steele. He informed me that he doubts green-fly being the cause of the stunted growth generally attributed to it. In proof of this, bushes were examined with the insect on them, some being stunted, others not. He is disposed to regard the stunt as due more to the general conditions of the life of the plant than to any external influence. It appears mostly on heavily pruned tea, the great abundance of shoots being, in Mr. Steele's opinion, more than the roots can nourish. The evil complained of is seen to be intensified by the stunted shoots being plucked, since the fresh shoots come up time after time stunted even long after the insect has disappeared from the plot. He is, therefore, of opinion that heavily pruned tea should not be plucked for some time until the shoots have recovered completely from the defective supply of food. He informed me that he had never seen unplucked heavy pruned tea affected.

Stunt showing after Plucking.

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591. Personally, I have all along been disposed to view with suspicion the opinion that green-fly was the cause of "stunted growth." While visiting Noakachari on the 24th April, I expressed my heretical views, and found that Mr. Wright was prepared to concur with me. It was, therefore, with considerable interest that I listened to Mr. Steele's observations. I drew his attention to the fact that the stunted twigs are abnormally thick and zigzag as if the descending sap had been arrested, thus causing a swelling of the joints. I further showed him by a section through a bud that the distortion is produced before the bud has unfolded, and not subsequently, for the axis of the young buds can be seen turning right and left before they have expanded. I further pointed out that the zigzag wood, 5 to 6 inches below the young buds must have been formed three or four months ago, and therefore anterior to the appearance of green-fly.

Descending Sap Arrested.

Distortion Produced in Bud. *Conf. with para. 602.*

Mr. Steele explained that green-fly begins about the middle of May. It is often checked by unduly hot weather, of even a week's duration. On the light pruned tea it comes and goes, rarely staying

Green-Fly Comes and Goes.

GREEN FLY.

more than three weeks or a month. On heavy pruned tea it stays much longer. The insect remains in the garden throughout the year, but only at certain intervals develops to such an extent as to specially attract attention. If, therefore, it be the cause of stunted growth, it is intermittent in its depredations.

Arsenic. *Conf. with paras. 381, 480, 559.*

592. REMEDY.—It will be found that **Mr. Bamber** experimented with insecticides (mostly solutions containing arsenic) in the treatment of this insect. For a time the plot of bushes syringed was freed from green-fly, but, after the first shower of rain, the insects again returned. **Mr. Bamber**, at the same time, made the observation that the fluid used by him, on several occasions, was seen to kill the tea shoots. These results are practically what I should have anticipated as likely to occur with the insecticide treatment of a winged insect pest.

Killed the Shoots.

593. But I am not disposed to propose any treatment for **Chlorita flavescens,** until it has been satisfactorily demonstrated that it is the cause of "stunted blight" and "crinkly blight." The more natural course is to suggest treatment when we have discovered that we are dealing with the actual cause of the disease, and have learned at least a few particulars of the life of the pest concerned. I would, therefore, urge on tea planters, the desirability of performing some practical experiments with the object of proving whether or not this insect is the cause of the diseased conditions complained of. All that would be necessary would be to have a few healthy bushes enclosed so as to prevent external influences, except green-fly purposely placed within the enclosure. If the bushes become stunted after, say, a couple of months, while a couple of bushes treated in every respect similarly except that no green-fly was placed within their enclosures, the inference might be admissible that green-fly was the cause of the disease. Another method might be to clean very carefully a bush in the middle of an affected plot, and enclose it with a fine wire gauze house having, perhaps, a couple of glass windows on the sides to admit light. A test bush alongside, with green-fly within its enclosure, would afford a useful comparison. If the bush from which green-fly had been rigorously excluded improved, while the other bush continued stunted and even got more stunted than the surrounding bushes in the open, it would be fair to assume that the exclusion of the insect very possibly had something to do with the recovery. Of course the act of enclosing bushes excludes light and air to a large

Experiment Essential.

PHROMNIA MARGINELLA.

extent, and these circumstances may have a beneficial or injurious influence. The experiments undertaken would accordingly have to be repeated once or twice, and varied in such a way as to remove the possibility of a wrong conclusion being formed.

Eggs.

594. The eggs of this insect (according to Mr. **Wood-Mason**) are laid upon the leaves of the tea. The insects, enclosed within the cage, might be found to lay their eggs, and in that case it would be instructive to follow a series of experiments similar to those indicated with mosquito to trace out the various stages in the life of the insect. Most important of all it would be desirable to note where and in what manner it punctured the tea and caused the injury that resulted in stunted-blight.

Does it Puncture the Tea.

Tea Leaves with Minute Brown Spots.

595. While by no means satisfied that **Chlorita flavescens** is responsible for what is attributed to it, I would wish, in conclusion, to say that practically all over Assam I observed tea leaves with minute brown spots on them, not a third the size of mosquito puncturings, which I utterly failed to account for. If this insect be proved to actually puncture the tea, it might be the cause of the minute brown spots to which I allude. I would suggest, therefore, that every leaf on the plants within the cages should be removed, that showed spots, stains or defects of any kind. For some time after the experiments, here recommended, are regarded as complete, the bushes should be retained within their cages in order to see by comparison of those on which the green-fly had lived with those kept free from that insect, whether any spots subsequently appear.

Family FULGORIDÆ.

68. (a) Phromnia marginella, *Oliv.*

References.—*Journ. Agri.-Horti. Soc. Ind., Vol. VI. n. s. Proc., 27th June 1879; p. xix, Proc., 18th Dec. 1879, p. xli; Ind. Mus. Notes, Vol. II., pp. 39-40, 92, 95-96, 166; Vol. IV., 42; Cotes, Insects and Mites, etc., pp. 36-37.*

(*Reg. No. 74, Tubes Nos. 64 and 245.*)

596. History.—This Homopterous insect is very common in Assam and Eastern and Northern Bengal. It has been repeatedly sent from tea gardens as found in the surrounding jungles, or occasionally as trespassing into the garden itself. The larvæ are conspicuous creatures with a white feathery coating of wax.

On one occasion this insect appears to have been sent to the Museum as an actual tea pest. **Messrs. Williamson, Magor & Co.**

furnished a sample of it from Mungledye, Assam, where it was said to have been found feeding on the tea and stopping the flushing. **THE TEA APHIS.**

In my experience it can hardly be classed as a pest, though I collected it on the tea both in Sibsagar and North Lakhimpur Districts.

Family APHIDÆ.

69. (a) Ceylonia theæcola, *Buckton.*

THE TEA APHIS—THE BLACK BUG OR BLACK FLY of most Assam Planters. **THE TEA APHIS.** *Conf. with para 46 (S).*

References.—Journ. Agri. Horti. Soc. Ind., Vol. IV., Proc., 18th Sept. 1873, p. xli (Assam); Vol. VII. Proc., 24th June 1885 (Kumaon); Tea Cyclopædia (Darjeeling Planter), pp. 44-45; Green, Insect Pests of Tea, pp. 45-55; Bamber, Chem. and Agri. Tea, p. 251; Ind. Mus. Notes, Vol. II., (pt. 1), 34-35; Vol. III., (pt. 4) p. 60; (pt. 5) 54; Cotes, Insects and Mites, etc., p. 38-39.

(Reg. No. 10, Tubes Nos. 28, 153, 160, 171 and 186.)

597. HISTORY.—The first mention of this insect occurs in a letter from Mr. G. F. Pinney, of Rungajam, Jorhat, Assam, in 1873. The samples furnished were submitted to Mr. J. Wood-Mason who pronounced them an undescribed species of Aphis. The next mention of what very possibly is the same insect comes from Kumaon. Messrs. George Henderson & Co. forwarded an extract from a letter (along with samples) from Mr. Norman F. J. Troup, of the Mulhakattyoor Tea Estate, Kumaon, in June 1885. A Darjeeling tea planter wrote on the same subject to *The Tea Gazette*. He speaks of it as a small black bug and fly which appeared immediately after pruning. To Mr. Green, however, belongs the honour of having pointedly made known this pest, and his account of it will be found replete with interest. Mr. Bamber refers to this aphis as a minute insect which will be found in most districts chiefly in the early season. It attacks the young shoots and gives them a black appearance. In August 1893 specimens were received at the Museum from Cachar. **First Mention in India.** **Described from Ceylon.**

598. The samples furnished by Mr. Green to the Indian Museum, were forwarded for examination to Mr. G. B. Buckton, who furnished a scientific description of the insect and referred it to a new genus CEYLONIA. His account of it will be found in the *Indian Museum Notes, Vol. II., p. 35.* Mr. Cotes' review of information was based chiefly on Mr. Bamber's statement of its existence in India and Mr. Green's account of it as a tea pest in Ceylon. **Published in Indian Museum Notes.**

599. It was found by me in every garden in Assam, in some to such an extent as to assume the position of an actual pest, in others **Met with in every Garden.**

Rhynchota (Aphidæ).

CEYLONIA THEÆCOLA.

only occasionally. Samples were sent by me to **Mr. Green** who has kindly compared them with the Ceylon insect and reported that they are identical.

600. Description.—This aphis lives in colonies, crowded together on the topmost leaf or two and the terminal bud of the flushing shoots, or on seedlings in the nursery. As already remarked, it is most prevalent in Spring, but may occasionally be seen throughout the year. The insects of each colony are of a dark brown to almost black colour, and in size not larger than the head of a pin. If examined under the lens, they will be seen to be either all wingless, or there may be a few winged individuals, crawling about among the wingless ones, or a whole colony may be winged. It will be found that the majority of colonies consist of the wingless form, with a few winged individuals scattered about.

Winged and Wingless.

The figure given by **Mr. Cotes** represents both the wingless and winged insects much enlarged. The wingless form will be found to have two teats (not shown in the illustration) and a pointed anal extremity, looking like a third teat. The body of the winged insect is also larger relatively to the other than represented, and it has only two teats in all, the anal projection shown in the figure is not present so far as I could find in the Assam insect.

Honey-yeilding teats. *Conf. with para. 616*

601. According to **Mr. Green** the male insect would not appear to have as yet been discovered and the winged and wingless females have both the power of reproduction parthenogenetically. They "are viviparous, and are capable of producing fresh colonies of the pest by their own unaided efforts." "I have frequently watched," continues **Mr. Green**, "the formation of one of these colonies. The female, either a winged or wingless individual, flies or crawls on to a new leaf, and commences to produce living young ones which settle themselves by her side and immediately plunge their beaks into the tissue of the leaf. Within ten or twelve days these new arrivals will be full grown and actively engaged in increasing their numbers until every available shoot is populated. Emigrants, meanwhile, will have wandered off to form new colonies on other bushes. In this manner the increase is so rapid that it has been calculated that a single aphis, if unchecked, could be ancestor of ten thousand million of millions (10,000,000,000,000,000) in three months' time. But most fortunately the many natural enemies of the insect are able to prevent this

Male Insect not Discovered.

Viviparous. *Conf. with para. 538.*

Adult Age

excessive increase. In England and other northern countries, a brood of males and oviparous females is developed at the approach of winter. Eggs are deposited, which remain dormant during the cold weather, hatching out in the following Spring into asexual viviparous females." **TEA APHIS.** **Males and Oviparous Females.**

In Ceylon, adds Mr. Green (and this may be true of India also) where vegetation continues throughout the year there is no limit to the asexual reproduction. I gave this subject some attention in Assam, but failed to find a male insect although the reproduction of an oviparous generation would seem essential to provide for the complete disappearance of the aphis for many months together, and its sudden and almost simultaneous reappearance on the Spring shoots all over the province. **Interesting subject of Enquiry.**

602. Depredations.—From the remarks already offered this pest can hardly be regarded as of no consequence. It occasionally occurs to a distinctly injurious extent, and might multiply, without any warning, to a degree previously unknown, and become then positively alarming. The women in gardens, where this aphis exists abundantly, often complain of the fingers being poisoned from the brown staining fluid produced from crushing the aphis in the act of plucking tea. But it must be borne in mind that this pest chiefly occurs in the nursery or on the early Spring shoots. In both cases it does more injury than at first sight appears. The young seedling can ill-afford to have the sap sucked from its terminal leaves and bud. It stops growing in consequence, becomes bark-bound and *banjhi*. It is not killed in most cases, and the injury done is disregarded, though it has received a severe check that may alter its shape by forcing out buds that may not be desired, and retard its growth so materially as to represent several months' delay in its reaching the flushing state. Insignificant though the depredations of the aphis may appear at the time, it has effected a permanent injury to the life of the plant. So in a like manner the Spring buds, especially upon a plant that has been severely pruned, or is otherwise unhealthy, may be so materially checked by the aphis that fresh shoots may have to come away from the wood before any progress can be made. **Poisons the Fingers.** **Injury to Seedlings.** **Permanent Injury.**

603. The following passages may be here given from my diary as descriptive of the depredations accomplished by the aphis :—

At Cherideo (visited 20th March 1895), Black-fly (**Ceylonia theæcola**) was very prevalent, both the winged and wingless states. These form separate colonies on adjacent leaves, the wingless in association with

Hemiptera (Aphidæ).

CEYLONIA THEÆCOLA.

Simultaneous Action.

larger and more reddish coloured larvæ or young insects, than are to be seen in the winged colonies. In both colonies the insects are arranged in lines along the leaf midribs and twigs. They suck the juices of the tea suddenly and altogether as if under command, then repose for a little and again simultaneously swing to one side, seemingly in the effort of straining. The proboscis can easily be observed to be deeply inserted.

Arranged alongside the Midrib.

The uniformity in which these aphides are arranged on one side or both sides of the midribs of the young leaves and along the flushing twigs and their synchronous movements, are very striking peculiarities. The young are usually crowded together, more especially on the twigs than on the leaves, and do not get fixed and arranged until maturity or possibly until the plant unfolds the next leaf above, which is to become their feeding ground.

This insect is reported to have never been seen so prevalent, in this garden, before the present year (1895), and indeed it may be said that the fresh shoots of many plants are almost entirely destroyed by it. The leaves as each colony dies or migrates are seen to be sharply folded along two lines, so that in transverse section they would be not unlike the transverse section of a soup plate. As the leaf elongates and widens, these lines become brown and punctured, and are then observed to be divergent from the base upwards. Ultimately the leaf becomes crumpled and withered, or may at times be seen to break off along the lines of **Ceylonia's** puncturings.

Wingless Colonies only.

604. At Dumar-dallang I found (April 5th) a variety of insects on the tea, including **Ceylonia**, fairly frequent and doing much damage. Small black-ants were always seen in attendance on the aphides. (*Tube No. 160.*)

At a garden visited on the 8th April (in the Moran Section of the Sibsagar District) I found the Assam plant attacked by numerous colonies of **Ceylonia**, but only the wingless condition, so far as I could find, and they did not move so methodically as at Cherideo. This aphis, in the opinion of Mr. M., is the cause of the leaves being punctured in the manner commonly ascribed to immature mosquito. (*Tube No. 153.*)

Causes of Minute Brown Spots.

Ant Nests formed Around Aphides.

Conf. with para. 609.

605. At a garden in the Nazira neighbourhood (visited 12th April), **Ceylonia** was found fairly abundant, and the black-ants that attend these aphides were also observed to cause the leaf or leaves adjoining to form a house like enclosure over the colony of aphides, the leaves being cemented by a black earthy-looking substance. Samples of the ants, of the **Ceylonia** and of the earth enclosure were preserved. Both winged and wingless forms of the aphis were common, the latter much the more numerous. (*Tube No. 171.*)

Apple-foliage-blight.

Conf. with para. 673.

606. At North Lakhimpur, **Ceylonia** was seen on one bush in Dirpai (July 7th, 1895) both winged and wingless on the same twig. Mr. Alexander thought this might be the cause of the scales seen on the apple-foliage-blight.* This is highly improbable and for many reasons. Only one bush seen with the apple-foliage-blight in Patalipam. Many gardens have so much of the black aphis in April that they should in that case have the apple-foliage blight on almost each alternate bush, which they have not. Moreover, the bushes have the apple-foliage-blight throughout their life.

The wingless **Ceylonia** have a long spine like a third teat on the anal extremity : the winged insects are simply pointed, but have no anal spine.

* See Mite No. 95 below. The divergent lines, caused in Mr. Green's opinion by the Mite, closely resemble those formed by **Ceylonia**.

The Tea Aphis.

607. REMEDY.—Under the subject of ladybird beetles (*p. 190*) above, I have already alluded to the larvæ of these insects being, perhaps, the most valuable of the Assam natural enemies of this pest. Other carnivorous larvæ will also be found to prey on it. In Ceylon **Mr. Green** tells us that "the larvæ of several hovering flies, belonging to the family SYRPHIDÆ subsist entirely upon aphides and are fortunately very abundant. They are leech-like grubs. One kind sets to work without any disguise, another conceals itself under a canopy of its slain victims. They are very voracious and exterminate whole colonies of the pest. The small pear-shaped pupa is fixed to the stem of the plant. The perfect flies, with banded bodies, like diminutive wasps, may generally be seen hovering over the diseased plants, or depositing their eggs upon the leaf amongst the aphides. Another little creature—the Aphis lion—assists in the war of extermination. This grub also piles up the skins of its victims upon its back, leaving only its head and long sickle-shaped jaws exposed. It is the larvæ of one of the delicate lace-winged flies. The eggs are deposited in clusters on the leaves, each at the summit of a long thin hair. The larvæ of several "ladybird" beetles materially help to thin the numbers of the pest. And a small shining black wasp (**Rhopalum? sp.**) after paralysing them with its sting, carries off the young aphides to store them in cells excavated in pith of mana grass as food for its own young."

TEA APHIS.

Natural Enemies.

Ladybird Beetle.

Conf. with paras. 331, 571, 614.

"But the most insidious of its many enemies is a minute ichneumon fly that lays its egg within the body of the living aphis. This egg develops into a tiny grub that gradually consumes the vitals of its host. Whole colonies of defunct aphides may sometimes be observed, each with a circular trap door cut in its black from which the parasite has escaped."

608. So far as I was enabled to learn, the larvæ of the ladybird beetle is the chief enemy of the aphis in Assam, but I repeatedly came across other larvæ devouring the aphides, so that with sufficient time for study no doubt it would be found the pest is kept in check in India by as complete an assemblage of enemies as in Ceylon.

609. The red and black ant (No. 57 above) which, many planters think, eats these aphides, is in that respect the planters' worst enemy, for it fosters and protects the aphides on account of the honey-dew secreted by them.

Black Ants.

Conf. with para. 605.

Rhynchota (Coccidæ).

TEA APHIS.

Insecticides.

610. The most interesting part of Mr. Green's investigations, in connection with this pest, may be said to be his study of the insecticides that may be used in its destruction. He found that wood ashes, powdered sulphur, and dry carbolic powder were unavailing, but that the aphis readily succumbs to kerosine emulsion or phenyle. On this subject he says, "A weak wash of kerosine emulsion or phenyle applied with a brush will instantly kill every aphis. It should be applied either in the evening or on a cloudy day. Hot sunshine upon leaves freshly drenched with kerosine is apt to scorch them. One part of kerosine emulsion to eighty parts of water will make a mixture strong enough to kill every aphis with which it comes in contact, while a still weaker mixture of phenyle—one part to two hundred and forty of water—is sufficient for the same purpose." "Watering the nurseries with a weak phenyle wash is a very simple cure. The phenyle should be applied in the evening and followed the next morning by a liberal supply of pure water."

Kerosine Emulsion.

Phenyle.

Family COCCIDÆ.

THE SCALE INSECTS OR SCALE-BUGS, ETC.

Affinities.

611. These curiously constructed and remarkably interesting insects constitute one of the most formidable assemblages of plant pests. They are comprised within a sub-division of the HOMOPTERA, which, as Mr. Green has pointed out, by their possession of horizontal wings, more or less completely over-lapping each other on the back of the insect, they are allied to the HETEROPTERA (or plant-bugs). They may be recognized by the female being wingless and fixed on the plant in the form of a scale; by the adult male having one pair of wings supplemented with a pair of hooked organs, representing the missing pair of posterior wings; by the legs in both sexes terminating in a single claw; by there being normally only one joint to the tarsus; and lastly by the absence of any mouth or feeding apparatus in the adult male. Mr. Green, from whom these diagnostic characters have been derived, gives the further particulars that the female may be recognized by the absence of any definite boundary, between the head and thorax; by the rostrum, or mouth parts, being situate far back on the under-surface of the insect; and lastly by the secretion, in greater or less quantity, of waxy, fibrous, or resinous matter, as a protection to the insect, which gets fixed to one spot at an early stage of its existence.

Female Insect.

The Tea Scale Insects.

612. Under this Family have to be placed some of the most destructive of plant pests, while a few species afford valuable economic products. The Green-bug (**Lecanium viride**) proved almost calamitous to the coffee industry of Ceylon, assisted as it was by the Black-bug (**L. nigrum**) and by the Brown-bug (**L. coffeæ**). So again, the dreaded Fluted-scale (**Icerya purchasi**), the Egyptian Cottony Cushion Scale (**I. ægyptiacum**), the Mussel-scale (**Mytilaspis pomorum**), the Purple-scale (**M. citricola**), the Long-scale (**M. gloveri**), the Mealy-bug (**Dactylopius destructor**), and many others, are well known dangerous pests of cultivation. Although fortunately none of the scale-insects hitherto found on the tea plant, have assumed alarming proportions, still they are present and may be said to be steadily sapping the life of the plants on which they are attached, and are becoming more securely established as tea pests. They have to account for the general want of tone observable in many estates and for the hide-bound stems so much complained of. It is of the greatest importance, therefore, that these insignificant-looking pests should be clearly recognised and their injurious action fully understood, not merely because of the present injury they are effecting, but, to a far greater extent, because of their possibilities of infinite mischief in the future. **Mr. W. H. Miles** in a lecture, delivered before the Calcutta Microscopic Society in 1895, very properly remarked :—"Though not wishing to appear as an alarmist, I fear that tea is threatened with a new danger, which may do more harm than any of its predecessors, judging by what has happened in other parts of the world. I would seriously impress on all connected with this great industry, more especially managers of gardens to be on the alert, and at the first indication of this pest, to adopt remedial measures at once to stamp it out, otherwise there is no telling what the consequences may be."

DANGEROUS PLANT PESTS.

Hide Bound Stems.

A New Danger to the Tea Industry.

613. **Mr. Green** very properly remarks that "it is a curious fact, in connection with scale insects, that particular species are liable—under certain circumstances, such as the accidental extermination or reduction of some natural enemy—to suddenly spring into prominence. Another great source of danger is the introduction of new species from other countries." Some of the most alarming scale and other insect scourges hitherto recorded, have been in consequence of the introduction of a species from one country to another. In its

Sudden Multiplication.

Danger of Introducing Foreign Insects.

Hemiptera (Coccidæ).

SCALE INSECTS.

original home the insect may have been comparatively harmless, because of its being kept under by its natural enemies. On getting to a new country, where these enemies do not exist, its facilities of multiplication, and thus its possibilities in the path of crop destruction, are limitless. A good example of this may be mentioned in the case of the **Phylloxera** of the vine. In its original home, in the Eastern United States, it was comparatively harmless, but in Europe and other countries into which it had unfortunately been introduced, it very rapidly threatened the very existence of vine culture. By way of a local manifestation of a sudden appearance and as sudden disappearance of what was possibly a scale insect, I might refer to the experience in Coonor and Kotagiri. In a recent issue of *Planting Opinion* the following passage occurs—" In one case a young extension at Kotagiri was dreadfully damaged, over 2,000 young trees being actually killed out by it, and many more being left very shaky. Curiously enough, since last December, the bug seems to be going off as rapidly as it came on, and this without any application whatever." It is to be feared that many useless methods of dealing with pests have obtained a fictitious reputation from their having been employed at the period of the natural disappearance of a pest.

Fictitious Reputation.

Natural Enemies.

614. It has long been known that the various species of ladybird beetle are the most formidable of enemies to scale insects. But the ladybird has its own enemies, and, in consequence, often cannot increase in number beyond an established balance. Taking advantage of the fact indicated above, that an introduced insect may suddenly multiply to an almost limitless extent, the very best results have been obtained by the introduction of the ladybirds from one country to another, in the hope that these may be able to successfully attack a plague of scale insects before they are themselves discovered and destroyed. A case to point may be mentioned in the marvellous results obtained by the introduction of the "Vedalia beetle" into California, which resulted, in a remarkably short time, in the extirpation of the fluted scale from the orange plantations of that country. For particulars regarding the Australian ladybird **(Vedalia cardinalis)** see the *Indian Museum Notes, Vol. III. (pl. 3), pp. 29-30.*

Vedalia Ladybirds. *Conf. with paras. 331, 571, 608.*

615. But as a set-off against the long list of destructive scale-bugs,

the useful species may be here mentioned briefly :—The cochineal insect (**Coccus cacti**) ; the lac (lakh) insect (**Tachardia lacca**) : the Chinese wax insect (**Ericerus pela**) : the Indian wax insect (**Ceroplastes ceriferus**), etc. **USEFUL SCALE INSECTS.**

616. Most of the scale insects (like the aphides) secret a sugary fluid much appreciated by several species of ants. Speaking on this subject **Mr. Green** says, "It was at one time supposed by planters that the ants which are so constantly in attendance upon scale-bugs were preying upon them, and the formidable "Red ant" (**Œcophylla samaragdina**) was actually imported into some estates with the view of exterminating black-bug on the coffee trees. This is now known to be quite a mistaken idea. The ants are attracted by a viscid sugary liquid emitted by the bugs, and which is in fact, their excreta. This substance is being constantly shed upon the surrounding leaves and proves very attractive, not only to ants, but to flies of all kinds, and even to bees and wasps. It is of the same nature as the "honey-dew," so abundantly produced by aphides. Far from feeding upon the bugs, I believe the ants actually transport them from place to place to found fresh colonies of them in convenient situations. It is certain that the small black nest-building ant (**Cremastogaster dohrni**), that is such a nuisance on some of our estates, invariably includes in its nests colonies of mealy-bugs (**Dactylopius**) and one or more species of **Lecanium.**" In the Assam gardens I have already said the red and black ant (**Cremastogaster contenta** No. 57 above) encloses the black aphis within its nest. Although I did not come across an instance, I have no doubt it uses also several species of scale-bug in the manner **Mr. Green** describes with **C. dohrni.**

Sugary Fluid.

Ants Useless against Aphides or Scale-insects.

Conf. with para. 609.

Scale Insects Protected by Ants.

617. In many cases a fungus will be found in association with scale-bugs. This subsists on the sugary exudation and is not itself directly harmful to the plant. Under the account given above of the mosquito (**Helopeltis**), I have alluded to this as being in all probability the "Sooty Bug" of the early writers, who apparently associated it with mosquito. The fungus will be found to grow on the upper surface of the leaf, the part upon which the sugary deposit would naturally accumulate. While distinctly very untidy-looking, it cannot interfere with the respiration of the plant very materially, since the stomata or breathing mouths are on the under-surface. It must, however, largely

Associated Fungi.

Conf. with paras. 514, 638-9, 837-8.

Cannot be Harmless.

Rhynchota (Coccidæ).

LITERATURE OF INDIAN SCALE-INSECTS.

Friendly Fungi. Conf. with para. 628.

exclude light, and, therefore, cannot be said to be harmless. Still its chief interest lies in the fact of its pointing the way to the existence of a dangerous scale-bug on the leaves and twigs of the plant, where the sooty fungus exists. But in one or two instances friendly fungi have been recognized, that is to say, fungi that prey upon, and destroy, the scale insects. The introduction of these where they do not already exist, is one of the methods of dealing with scale insects that should receive careful consideration.

618. I have gone into these details regarding the scale insects collectively, because so very little is known of the individual characteristics and methods of depredation of the species found on tea. Let me add by way of conclusion, that I have derived the very greatest assistance from the perusal of **Mr. E. Ernest Green's** most admirably conceived and beautifully illustrated forthcoming work—"The Coccidæ of Ceylon." Unfortunately only the first part of that invaluable work has come to hand as yet, but I commend it to all planters who may wish to look into the matter of scale-bugs. It is published by **Messrs. Dulau & Co.** at £5 for the complete work, and part one, already available, contains thirty-three full page coloured plates. It is intended to describe all the species of Coccidæ met with in Ceylon—most of which doubtless occur also in India—but the interest to the planter lies in the fact that it will describe all the forms met with on tea, coffee and other crops, so that the work has a practical value, besides its very high scientific merit. Speaking of the Coccidæ, I may as well add that the Indian Museum Notes will also be found to contain several papers of great value. In Vol. I., pp. 59-62, **Mr. W. M. Maskell** figures and describes two forms of DIASPINÆ that occur on the tea and gives full particulars of the LECANIINÆ Scale-bug **(Eriochiton cajani)**, that has appeared on the *tur* or *arhardal* crop **(Cajanus indicus)**. Then **Mr. R. Newstead** has a paper in Vol. III. (pt. 5), pp. 21-32, on the scale-insects of Madras in which he figures and describes the male of **Ceroplastes ceriferus**—not previously seen. Lastly, **Mr. Green** furnishes a provisional catalogue (Vol. IV., 1-10) in which he enumerates 72 species of scale-bug. A most instructive paper by **Professor L. O. Howard,** M.S., Entomologist, U. S. Department of Agriculture on the *Life History and Habits of Scale Insects*, will be found in the Year Book of the United States Department of Agriculture for 1894, pp. 250-276.

Scale Insects.

70. (a) **Aspidiotus lataniæ**, *Signoret* (**A. transparens**, *Green*). YELLOW BARK LOUSE.

THE TRANSPARENT SCALE BARK LOUSE.

References.—*Green, Coccidæ of Ceylon, pp. 49-50, Pl. VIII.; also Insect Pests of the Tea Plant, pp. 22-25; Ind. Mus. Notes, Vol. II., 168; III. (pt. 4), 52; Cotes, Insects and Mites, etc., 41; Journ. Agri.-Hort. Soc. Ind., Vol. X., Proc., March 30th, 1894, pp. 37-38.*

(*Reg. No. 115.*)

619. HISTORY.—**Mr. Green** tells us that this species is hardly of sufficient abundance to rank as a pest. It may be recognized as consisting of small transparent scales on the under-sides of the leaves. Its identification on Indian tea rests on **Mr. Cotes'** recognition of a few scales on a tea leaf sent from Jalpaiguri (*Conf., Agri.-Hort. Soc. Journ.*). I did not come across it in Assam.

71. (b) **Aspidiotus cyanophylli**, *Signoret.*

References.—*Green, Coccidæ of Ceylon, p. 51, Pl. IX.*

(*Reg. No. 116.*)

620. **Mr. Green** tells us that he has found this scale-bug on the undersides of the leaves of tea in Ceylon. It has not as yet been recorded as met with in India, but it is a very widely distributed species.

72. (a) **Aspidiotus camelliæ**, *Signoret* (**Aspidiotus flavescens**, *Green*). Yellow Bark Louse.

THE YELLOW BARK LOUSE.

References.—*Green, Coccidæ of Ceylon, pp. 60-61, Pl. XIII.; also Insect Pests of Tea Plant, pp. 21-22; Bamber, Chem. and Agri. Tea, p. 252; Ind. Mus. Notes, Vol. II., 59, 168; III., p. 52; Cotes, Insects and Mites, p. 41; Howard, U. S. Year Book of Dept. of Agriculture for 1894, pp. 261-3.*

(*Reg. Nos. 87, 91 and 117.*)

621. HISTORY.—**Mr. Green** was the first to make known the existence of this as a tea pest. **Mr. Cotes** tells us that it has been reported from Assam and Kangra. The samples collected by me personally and also those procured from Kangra have, however, been identified as being **A. theæ**, *Mask.*, so that it seems probable Kangra should be removed from the habitat of this species. **A. camelliæ** was found, however, by me almost frequently in Assam, and I have also two separate sets of collections of it from Darjeeling (furnished by **Messrs. Devenport & Co.**), so that it may be accepted as fairly general in the Indian tea districts. It is an extremely abundant and widespread species: it has been recorded from England, Portugal, New Zealand,

ASPIDIOTUS

New South Wales, Hawaii, the United States, in addition to Ceylon and India.

Crowded at Leaf Axils.

622. DESCRIPTION.—The scales of this species are of a pale-yellow colour, with a reddish or brown central mark, and they are somewhat hairy. They resemble minute oyster-shells, with the younger scales clustering around and often overlapping the older ones. They are crowded together near the axils of the leaves, extend along the leaf stalk, and to some extent up the midrib. In consequence they are thus fairly conspicuous objects and should be easily enough recognized.

Uprooting Plants Recommended.

623. DEPREDATIONS AND REMEDY.—Mr. Green says of this species, "Badly infected plants seldom recover their vitality, the stems become thin and wiry, and seem very reluctant to throw out fresh shoots. There is nothing to be done, but to take out the plant and supply another in its place. The diseased plant should on no account be allowed to remain beside the new one, or this latter also will speedily become infected." So far as I have been able to judge, firing bushes or plots of tea affected by this pest, is fairly successful. The plants receive a severe shock, no doubt, and those that were nearly dead in any case die outright, but a large percentage of the bushes are saved which, as Mr. Green very properly remarks, are certain to be killed, when once this pest becomes fairly established.

Firing the Bushes should be tried.

73. (a) Aspidiotus theæ, *Mask.*

Kangra Scale Insect.

THE KANGRA SCALE INSECT.

References.—*Maskell, Ind. Mus. Notes, Vol. II., (pt. 1), p. 59 : Journ. Agri.-Horti. Soc. Ind., Vol. VIII., n. s. Report ending December 1889, pp. 435-36.*

(*Reg. No. 90.*)

624. HISTORY.—This insect was described by Mr. W. K. Maskell (*Ind. Mus. Notes, Vol. II., (pt. 1), p. 59*) from specimens said to have been furnished to him from "Assam, Kangra Valley, etc." Subsequently Mr. Cotes (*Insects and Mites, etc., p. 41*), gave **A. theæ**, *Mask.*, as a synonym for **A. flavescens**, *Green.* The samples collected by me in Kangra, as also those furnished by Messrs. Shaw, Wallace & Co., from Holta Garden, Kangra, were submitted to Mr. Green for favour of opinion. The following passage may be given from his reply : "Your specimen is **Aspidiotus theæ**, *Mask.* That species does not occur in Ceylon though closely allied to

A. trilobitiformis, *Green*." It would thus appear that the Assam and Darjeeling insect is **A. camelliæ,** *Signoret* (**A. flavescens,** *Green*), but that the Kangra insect should be kept distinct under name given to it by **Mr. Maskell.** It is incorrectly known to the Kangra planters as a species of **Lecanium,** and its most ready eye-mark, from the characters already given for **A. camelliæ,** is that the scales are more widely distributed along the twigs and more crowded at the points of branching than within the leaf axils. It would seem as if this might be a more severe pest than the form met with in Assam and Darjeeling.

THE KANGRA SCALE INSECTS.

Wrongly known as a species of Lecanium.

I would not wish it, however, to be supposed that I think it impossible for Kangra to possess any other tea scale insect than the one here dealt with. I speak of my own collections and the information I have been able to procure. I came across no species of **Lecanium** in Kangra, nor do I know what is meant by **Lecanium theæ** said to have been determined by **Mr. E. T. Atkinson** (*Ind. Mus. Notes, Vol. I.,* (*pt. 4*), *p. 209*) an insect reported to have been obtained from Kangra.

625. Depredations and Remedy.—The remarks already offered (*para.* 623) apply with equal force to this insect. Kangra may be said to have but two pests of any consequence, the present one and the *barota* or basket-worm (**Amatissa consorta**). Neither should be viewed lightly, since it is possibly an accident, more than anything else, that they have not as yet assumed gigantic proportions.

The Basket worm. *Conf. with para. 379.*

In the Journal, Agri.-Horticultural Society, particulars will be found of a treatment with kerosene emulsion that seems to have been fairly successful. If only a slight attack exists that insecticide may suffice and should of course be tried, but no scale insect ought to be allowed to gain ground while experiments are being made with different methods of treatment. It would in that case be preferable to sacrifice a few bushes than risk a large number.

74. (c) Aspidiotus dictyospermi, *Morgan*, var. arecæ. [*Cockerell.*

(*Reg. No. 89.*)

626. History.—Among the specimens furnished by **Messrs. Shaw, Wallace & Co.,** from Holta, I found three leaves of what appear to be tea. These had the upper surface completely covered with a scale insect quite different from the previous species. This, **Mr. Green** has

Another Kangra Scale Insect.

FIORINIA FIORINIÆ.

been good enough to inform me, is a species that he has hitherto found on rose stems, ivy and **Cycas revoluta.** In the Kangra sample it occurs on the leaves, not on the twigs, but unfortunately I am not sure of these leaves being tea. In some respects they are remarkably like tea, but are too thick and leathery and the veins too far apart and too square to the mid-rib. If it is tea, it must be a strikingly peculiar hybrid.

75. (c) Fiorinia fioriniæ, *Targ. Tozz.* (F. palmæ, *Green*: F. camelliæ, *Comstock, Agri. Report, 1880, p. 329*).

References.—*Green, Coccidæ of Ceylon, pp. 94-95, Pl. XXVI.* *(Reg. Nos. 33, 88, 118.)*

The Assam Scale Louse.

627. HISTORY.—Mr. Green writes me that, since the date of publication of the account of this insect (in his *Coccidæ of Ceylon*), he has lately found it on tea, but confined to low *jat* China bushes. This is without doubt the most prevalent of all forms of scale-bug or scale-louse in Assam, and is by no means unknown in Kangra. I have no personal acquaintance with the other tea districts of India, but should be much surprised were it not found in these as well as in the localities I have personally explored. It was certainly not found by me to be confined to low *jat* bushes, though I never saw it on any plant that did not manifest the same unkempt and dirty appearance. The leaves were invariably coated with dust, especially the under surfaces. This long, narrow and brown scale-louse might in fact be said to be buried in the mud adhering to the leaf. It lives on the under-surfaces of the leaves, and may sometimes be seen in hundreds on the same leaf, sufficiently numerous to give it a dirty brown appearance. I presume the mud may possibly adhere to the leaves, in consequence of the sugary exudation produced by the louse, but whatever be the explanation of the circumstance mentioned, it is so invariably the rule as to hardly escape notice, and must greatly interfere with the respiration of the leaves. The plants are sickly and unproductive. The insect may be described popularly as a long narrow chestnut-coloured scale, with a ridge down the middle. It shows very frequently smaller scales escaping, as it were, from the top and near one extremity.

Unkempt Bushes.

Respiration of Leaves.

Parasitised by Fungus. *Conf. with paras. 617, 645.*

628. DEPREDATIONS AND REMEDY.—After what has been said, it need hardly be added that this pest (insignificant though it may appear to the planter who may find here an affected bush and there another), is a dangerous insect to neglect. Mr. Green has kindly furnished me

with a specimen showing the scale parasitised by a fungus. His remark on the same may be here quoted: "If this Coccid should become troublesome in the Indian tea districts, it would be easy to introduce this fungus if it does not already exist." The fungus is not at present found in India so far as my experience goes, and it certainly would be worth while to obtain a supply of the fungus. But, in my opinion, a bush, once badly attacked by this scale-louse, will never recover. It is necessary either to collar prune down to the ground, and to instantly burn all the prunings, or then to fire the bush first and prune later as may be required. The advantage of firing the bush as it stands is that the pest is killed without any chance of a wider distribution being afforded through shaking, on carrying away the prunings. **THE WHITE TEA-LEAF LOUSE.**

76. (a) Chionaspis theæ, *Maskell.*

WHITE TEA-LEAF LOUSE. **WHITE TEA-LEAF LOUSE.**

References.—*Maskell Ind. Mus. Notes, Vol. II. (pt. 1), p. 60; Green, Insect Pests of the Tea Plant, 12-18; Ind. Mus. Notes, Vol. I. pp. 188-190; II., 59, 60, 168; III., 25; (pt. 4) 60; IV, 42; Journ, Agri.-Horti. Soc. Ind., Vol. X., Proc., 25th Oct. 1895, p. 328; Bamber, Chem. and Agri. Tea, 252; Cotes, (in part) Insects and Mites, etc., p. 39.* ***Conf. with para. 614.***

(*Reg. Nos. 26, 119; Tubes Nos. 206, 268: botanical specimens No. 11939.*)

629. HISTORY.—The first mention apparently of this pest on Indian tea is in connection with the specimens procured from Kangra and sent to **Mr. Maskell** for determination. **Mr. Green**, as he himself has pointed out, made the unfortunate mistake of viewing the female scale of **C. biclavis,** *Comst.*, and the male scale of **C. exercitata** *Green*, as constituting one species. In consequence he called this "the tea bark louse," whereas the species lives entirely on the leaves. **Mr. Cotes** followed the above error, so that his article is a combination of the peculiarities of this and the next species.

630. The male scale will be recognized as little patches or colonies of white waxy flakes, neatly arranged on the leaves of the tea plant. The very natural difficulty is at once suggested, on viewing these colonies, of the improbability of the female being able to reach the leaves in order to deposit the germs of these male scales. As a matter of fact, however, the puparia of both sexes are to be seen on the leaves. The male scale (or puparium) may be expressed popularly as a small yellow pellicle placed at the extremity of a structure that consists of three white waxy ridges, parallel to each other. The **Colonies of White Waxy Flakes.**

CHIONASPIS BICLAVIS.

female puparium is very much larger ($\frac{1}{10}$th inch long), is of a light brown colour, in shape pyriform, flat, with a brownish yellow pellicle at the narrow extremity. The colonies of male puparia are very plentiful, the female ones comparatively rare and dispersed over the leaves. The adult male has not as yet been discovered.

Mr. Cotes makes the very practical remark under this species that "In all scale insects the question of dispersion is an important one for, owing to the adult female being stationary, it is only the newly hatched larvæ which are able to travel from bush to bush, and thus spread the evil. It is important, therefore, to ascertain at what period of the year the larvæ emerge and the extent to which they are liable to be carried by the winds."

Common but not Materially Injurious.

631. Depredations.—So far as is known, this species is confined to the leaves, the colonies of male scales (or puparia) being on the upper-surface, and the female very often below. They must of course abstract a large amount of sap from the plant, but, so far as I could discover this insect, though common here and there in Assam, nowhere exists so abundantly as to cause material injury; I have recently, however, received from Darjeeling twigs of tea with the leaves almost white from the numerous colonies of this louse.

632. Remedy.—It might be greatly mitigated by sending out children to strip the leaves, seen to bear colonies of male scales, through the fingers. That would no doubt kill the males and very often the females also. Should the pest ever assume serious proportions, it should be treated in the same manner as for all other scale insects.

77. (b) Chionaspis biclavis, *Comst.*

Tea Bark Louse.

THE TEA BARK LOUSE.

(*Reg. No. 120.*)

633. History.—So far as I can discover, this species does not exist in India. At Patalipam I found the barks of manybushes cracked and splitting off in the manner peculiar to this species, but I could not be sure that I had found the scale. Mr. Green has been good enough to furnish me with a type specimen. His remark recorded on it may be here quoted: "A very inconspicuous species—the scales looking like small blisters on the bark. Often present in large numbers and responsible for hard wood and short flushes."

This is the insect described in the greater portion of Mr. Green's **Aspidiotus theæ** (*Insect Pests of the Tea Plant*) and, as already

remarked, it is the female insect of **Mr. Cotes'** account of **Chionaspis theæ** (*Insects and Mites, etc.*). SCALE INSECTS.

78. (a) Chionaspis prunicola, *Mask., var.* theæ, *Mask.*

634. This has been described as a tea pest in the *Indian Museum Notes* (*Vol. IV., p. 60*), but no locality has been recorded for it.

79. (b) Orthezia insignis, *Dougl.*

(*Reg. No. 125.*)

635. This very troublesome pest seems to have been introduced into Ceylon on ornamental plants. **Mr. Green** informs me that it occurs on **Lantana,** (a plant plentiful in some parts of Assam) and that it spreads to the neighbouring tea. To the naked eye it looks like little particles of white wax. It is a dreadful scourge and must be dealt with promptly should it appear. So far as I am aware however, this pest has not as yet found its way to tea in Assam. **Mr. Green** writes me that he has met with the pest crowding into the young shoots. He adds that the infested area in Ceylon has been fired and the pest apparently thus exterminated. Dangerous Pest.

80. (b) Pulvinaria psidi, *Mask.*

(*Reg. No. 126.*)

636. **Mr. Green** has been good enough to furnish me with a sample of this insect which, he says, is sometimes present in injurious numbers on individual tea bushes. I have not come across it on tea in India. It might be described as looking like small irregular white patches of paint on the under-surface of the leaves.

81. (c) Eriochiton? *nov. sp.*

(*Reg. No. 86 ; botanical specimens No. 9060.*)

637. History.—On the 19th of April 1897, **Messrs. Devenport & Co.** forwarded, for examination and report, samples of a pest which had appeared in The British Darjeeling Tea Company's Gardens, Darjeeling. The leaves on their uppersurfaces were densely coated with a black sooty fungus, and on the undersurfaces, more especially near the midrib, bore numerous long pure white scales, that had a tuft of waxy hairs arranged along a medial ridge. This seemed to me a remarkably interesting and possibly new Coccid, so that I took steps to obtain expert opinion on it. A Darjeeling Scaley-bug.

638. **Mr. W. T. Thiselton Dyer**, Director of Kew Gardens, was good enough to inform me that **Mr. George Massee** had identified the fungus as **Capnodium Footii**, *Berkl. & Desmoz.* **Mr. Dyer** wrote that

Rhynchota (Coccidæ).

ERIOCHITON SP.

Conf. with paras. 46 (2), 837-8.

this fungus had not previously been recorded as met with in India, but that it was common on insect-infested **Camellias** in cultivation, and also blackened the lime trees (**Tilia**), appearing in association with the honey-dew aphis.

639. A sample of the Coccid was sent to the British Museum, the result being that **Mr. Chas. O. Waterhouse** referred me to **Mr. Green**, of Ceylon, as the person most likely to be able to name the insect, but he added there was nothing the least like it in the British Museum collection. I had, at the same time, furnished a sample to **Mr. Green** along with the suggestion that it might prove a species of the ALEURODIDÆ. **Mr. Green's** reply was as follows:—" I believe this to be a true Coccid, not an Aleurodid. The examples consist of the empty puparia from which the winged males have made their escape. The few large waxy patches are the remains of the scales and eggs, but none of the adult females could be found. A single mutilated half-grown larvæ shows it to be LECANIID and apparently belonging to the genus **Eriochiton** (*Conf.* **E. cajani**, *Ind. Mus. Notes, Vol. II. (No. 1), p. 61.*)"

Scot Blight.

It seems probable that the author of *Notes on Tea in Darjeeling (p. 53)*, may be alluding to this blight under the heading "Soot Blight." " It is a small insect with a sooty covering, which makes the trees look fearful and stops all flushing. Luckily, this is not common, and, as a rule, only one or two trees will be found on a garden."

640. DEPREDATIONS AND REMEDY.—**Mr. Sproull**, who had furnished the samples, wrote in his letter of the 14th April, " I plucked these leaves from a tea bush in Nigali (at an altitude of 4,500 feet) this morning. There are several others similar adjoining. The leaves had quite a black appearance, and on examining them I found the lower sides covered with an aphis. They certainly do harm to the bushes; these bushes were in good health quite lately, and other bushes around the ones attacked are looking and flushing well, while the attacked ones are black and no flushing coming out of them. I have never seen tea bushes so attacked before, although I have seen these lice-like insects on Poinsettias." As this is probably a new Coccid to India could it have been introduced on ornamental shrubs, such as the Poinsettia (**Euphorbia pulcherrima**)?

Allied to the Coffee-bug.

641. In the correspondence that ensued, I stated that the insect was certainly not an aphis, but a much more dangerous pest, one of

the scale-bugs, perhaps, not very remote from the Coffee-bug. Washing with kerosine emulsion might stop it; but, if only a few bushes are affected, I would recommend, as more effectual, that they should be at once fired. If below each bush and amongst its branches a few handfuls of dry straw are placed and then ignited, the sudden flame produced will char all the leaves and twigs and completely eradicate the blight. Only the very sickly bushes will be thereby killed. The flushing will be retarded for a month or two, but the cure will be complete. As a rule, it is not wise to fire bushes much after March. If later than that, the shock is very much more severe, and the flushing may not be resumed before six or eight or, perhaps, eighteen months. But even a delay, such as I have indicated, would be preferable to the bushes being killed and the disease extended over the estate. Diseased bushes of course suffer more severely from being burned in the manner proposed than healthy ones accidentally fired, but if even 50 per cent. are saved and a troublesome disease eradicated, the gain is distinct. Other less severe methods of treatment may possibly give a higher percentage of bushes saved, but they involve the risk of the disease spreading or even being artificially distributed in the act of cutting down or of constantly visiting and handling the bushes. In a subsequent letter (26th April), **Mr. Sproull** wrote, " there were about a dozen bushes attacked, the leaves of which were all black and appearing as if they had been dusted with soot. " " I will carry out your suggestion as to burning. " On the 14th May, **Mr. Sproull** replied, to my request for more specimens that he was sorry he could not supply any as the bushes had been burned and no more of the blight could be found in any other part of the garden.

SCALE INSECTS.

Firing Recommeneded.

Conf. with paras. 649, 767-8, 774, 777-8.

Percentage.

642. On the 19th July **Mr. Sproull** *informed* me that a fair percentage of the bushes that had been burned, were again under leaf. Many of the bushes seem to have been so badly attacked with the scale that they were nearly dead before being fired. Speaking of the advantages of firing circumscribed plots of tea, badly affected by blights, **Mr. Sproull** adds, " I do not think anything better than fire. It is cheap, handy, always available. One knows from experience how great a quantity of fire it takes to kill a bush as seen when abandoned portions are again reclaimed or along the edge of cultivation after being scorched by jungle fires. "

Result.

Hemiptera (Coccidæ).

LECANIUM COFFEÆ.

82. (b) Lecanium viride, *Green.*

THE GREEN-BUG.

(*Reg. No. 121.*)

SCALEY BUGS.

83. (b) L. nigrum, *Nietner.*

THE BLACK-BUG.

84. (c) L. coffeæ, *Walk.*

THE BROWN-BUG.

(*Reg. Nos. 95 and 122.*)

643. I propose to deal with these three insects conjointly, since, so far as I have been able to discover, only one of the three, *viz.*, **L. coffeæ**, occurs on tea in India. **Mr. Green** tells us that green-bug, though it killed out the coffee in whole districts, has fortunately not seriously attacked the tea. The brown-bug, on the other hand, he says, is common on the leaves and stems of tea, and the black-bug, though originally described from coffee, is now seldom seen on that plant. **Mr. Green** makes no mention of its having appeared on tea. In the *Indian Museum Notes* (*Vol. I.* (*No. 2*), *pp. 113-122*) will be found a useful paper on these three species. It reprints, by permission, **Mr. Green's** pamphlet "*Observations on the Green Scale-Bug,*" and gives his comparative series of drawings in illustration of the various stages in the life of each of these dangerous pests. The article in the *Museum Notes* furnishes also the particulars and results of the experiments with kerosine emulsion as a cure for bug.

644. Of the three species, **L. viride** has hitherto proved the most dangerous, but fortunately has not, so far as is known, found its way to Assam if indeed it exists on the tea anywhere in India.

References.—*Gardner in Hooker's Journ. Bot., Vol. II.* (*1850*), *pp. 353-360; II., pp. 1-9; Pl. XII.* (*possibly L. coffeæ and L. nigrum conjointly dealt with and figured in this paper*) *; Nietner, Coffee Tree and its Enemies ; Green, Observations on the Green Scale-Bug ; Green, Insect Pests of the Tea Plant, pp. 81-88 ; Bamber, Chem. and Agri. of Tea, 252 ; Ind. Mus. Notes, Vol. I., 49, 113, 122 ; II., 168 ; III., (pt. 4) 18 ; IV.(No. 1), 9-10 ; Cotes, Insects and Mites, etc., 41-43.*

BROWN-BUG. *Conf. with para. 46 (1).*

645. HISTORY.—So far as I know, neither of the bugs here dealt with had been found on Indian tea prior to my discovery of **L. coffeæ** in North Lakhimpur. I found it on two occasions, but both on the North bank of the Brahmaputra. Samples from these collections were sent by me to **Mr. Green** for favour of examination, and the

following passage from his reply may be usefully given: "Your sample No. 95 shows the adult and immature stages of **Lecanium coffeæ**, *Walk.* It is occasionally very injurious to individual tea bushes here, but only on such as are sheltered from rain. Many of the scales supplied by you have been killed by a parasitic fungus which has completely destroyed the tissue of the insects and developed into small orange-coloured nodules upon the twigs." SCALE INSECTS. Parasitised by a Fungus.

The specimens collected by me were not found under shade in any way, they occurred in the middle of flat expanses of tea. I do not even think there were trees near by, but unfortunately I did not make a record in my diary on that point. The one set of specimens was collected at Dirpai on the banks of the Subanseri river, but in association with **Ceroplastes myricæ**. The other at Patalipam, and this was the sample parasitised in the manner mentioned by **Mr. Green.** Associated with a Wax Insect.

646. Description.—The full-grown female scale in my Patalipam collections is almost globose, is of a pale chestnut brown colour and somewhat polished. When younger, it is an oval scale with a strongly marked longitudinal ridge and two transverse bands. The larvæ are active pale canary yellow or almost lemon yellow creatures that move fairly actively for a time. Like all the other species of this genus, they have an anal sinus with two short hairs arising within it. The male has a smaller more elongated or linear scale which never becomes globose, and, when mature, is almost transparent revealing the pink chrysalis which in time gives forth its minute winged red fly. The insect found at Dirpai may possibly prove a new species closely allied to **L. coffeæ,** and I venture, therefore, to give here the description of it from my diary:—In the mature state these are tortoise-like creatures. They are pale straw-coloured, when young, turning to brown and mottled with a darker shade. In shape they are elliptic in outline, smooth with one longitudinal fold, and two transverse horizontal ones over the globose body. From beneath the mature bugs, larvæ were seen to escape. These are so small, when they first emerge, that they can hardly be recognized by the naked eye, and even, when localized by a lens, are difficult to see. Possibly New Species.

647. The larvæ are remarkable creatures, pale straw-coloured, almost obcordate in outline, the anal extremity being bifid, and having

LECANIUM COFFEÆ.

a thickened elongated tail-like structure within the sinus and two long anal horns on either side. The anterior extremity may be said to be broad, somewhat rounded with a minute acuminate beak. The body gives indications of being articulated into eight sections, and carries bifid hairs on the margin of the flattened wing-like expansion, corresponding to these sections. The eyes are large black situate behind the point of origin of the flapper-like large antennæ. These are seven-jointed and very hairy.

I could see no proboscis though I looked at many larvæ, but their active life is so short that they may be said to become fixed before one can pick them off the twigs. They are curious trilobite-looking creatures that crawl from beneath the margin of the mother bug, advance for about a quarter of an inch from the parent, and in a few minutes loose the power of locomotion and become fixed. The proboscis is then produced from below the body, and inserted into the plant. Some of the larvæ seen were a little more elongated than the others, and had two pinkish bands across their bodies: these appear to be the males. These larvæ grow readily, and on becoming fixed the legs and flapper-like antennæ disappear, the eyes become obscure, as also the semi-articulated condition of the body. They then swell up in shape, becoming almost globose, lose entirely the form described, and assume the adult condition.

Proboscis Produced on becoming Fixed.

648. Depredations.—On both occasions where I met with the brown-bug in Assam, my attention was attracted to the bushes by their black sooty appearance due to the upper-surfaces of the leaves being coated with a black fungus, apparently the same species as occurs in association with the bug in Ceylon. The bug lives on the under-surfaces of the leaves and on the twigs and shoots. The female insect, on its becoming fixed, inserts its delicate hair-like proboscis and sucks the juices of the tea. The plant is thus gradually impoverished and soon shows the extent to which it is suffering by discontinuing to produce flushing shoots.

Black Fungus.

Bushes Discontinue Flushing.

649. Remedy.—This pest must be treated in exactly the same manner as with all other scale insects. Whenever seen, the bushes should be carefully brushed with kerosine emulsion. Should the disease be found securely established and be giving indications of expanding, rather than risk the larvæ being blown by the wind or carried by the clothes of the coolies far and wide, fire the plot. It is more economical

Fire Recommended.

to lose the bushes than to risk a wide distribution of this or any other scale-bug. **SCALE INSECTS.**

85. (b) Lecanium formicarii, *Green.*

650. Through the kindness of **Mr. Green**, I have had the pleasure to receive a specimen of this insect. I did not come across it in Assam, but mention it as a pest that may likely be found. It occurs in Ceylon within the mud hives formed by the ant, **Cremastogaster dohrni**. A closely allied ant is common in Assam, and doubtless, when these mud hives are more carefully examined, this or an allied **Lecanium** will be found within them. The ant imprisons the scale insect in order to have a convenient supply of sugary fluid. **Found within Ant Mud Hives.** *Conf. with para, 497.*

86. (c) Lecanium, *sp. nov.* **A large Scale-bug.**

(Reg. No. 124, Tube No. 293.)

651. From **Mr. J. A. Thomson**, of Ligri Pukri, Nazira, Assam, I had the pleasure to receive a most interesting species of **Lecanium**. Specimens of this were forwarded by me to **Mr. Green** who has replied: "This is a handsome large species of **Lecanium** which I believe to be quite new and which I propose to call **L. watti**." The scales are about ½ inch long and are of an oval shape and a thin cartilagenous texture. The scales are found attached to the shoots and completely encase the twigs, while the leaves are covered with the soot-like fungus that accompanies most species of this genus.

This could be a formidable pest, but fortunately it seems to be very rare.

87. (c) Ceroplastes myricæ? *Linn.*

(Reg. No. 96, botanical specimens No. 11961.)

652. History.—On reaching North Lakhimpur, one of the first questions I was asked was, whether I had come across the lac (*lakh*) insect as a tea pest. On being taken to a plot of bushes in Dirpai with this disease on them, I fully appreciated the applicability of the description of lac pest, for every twig was seen to be completely encrusted with a thick resinous substance that I soon saw was not lac, though by no means a distant relative of that insect. It was a species of **Ceroplastes** that **Mr. Green** has been good enough to identify for me as **Ceroplastes myricæ?** *Linn.* **Supposed Lac-Insect as a Tea Pest.**

Hemiptera (Coccidæ).

CEROPLASTES MYRICÆ

653. DESCRIPTION.—It was with considerable astonishment that I proceeded to examine this most curious pest—new entirely to my already large list of insect enemies to the tea plant. I was told that, although it had nowhere appeared to an alarming extent, it was well known in Upper Assam, especially on the North bank. I had not come across it before, and was not a little surprised that the **Ceroplastes** was invariably associated with the **Lecanium** that I have provisionally described above, under the same specific heading as given to my previous collections, *viz.*, **Lecanium coffeæ.** Speaking of the fairly common and significant association of two scale insects together, I may add that the other day, in Calcutta, I came across **Ceroplastes myricæ** growing on the leaves of a Cycad, but in this case it was associated as Mr. Green tells me with **Aspidiotus orientalis,** *Newst.* This curiously interesting further discovery suggests the not very improbable inference that **Ceroplastes myricæ,** as a tea pest, may have been derived from the very frequently seen Cycads in the planter's flower garden.

Waxy-bug found on Tea and also on a Cycad.

Associated Fungus.

654. Not only were the two LECANIIDS mentioned, invariably found together on every tea bush examined by me (affected by this pest), but they were also accompanied with the black sooty fungus so common on tea infested with scale-bugs. It perhaps is hardly necessary for me to attempt a detailed description of this insect, but the following observations taken from my diary may help the planter to recognize the pest:—These waxy-looking bugs may be said to be pale pink, sea-anemony-like creatures that have on either side of their waxy encasement two wavy white folds. The encasement may be spoken of as comprising an outer more or less flattened rim, with a central globular portion, so that in main shape the waxy structure is not unlike the Parsi felt-hat. At one extremity, and situate on the outer rim, there are three circular bodies, two right and left (which may be spoken of as (*b*) (*b*) and one in the middle (*a*)—the anal orifice. While, right on the summit of the globular central portion, there is a crater-like depression of a pure white colour (*c*), and in the centre, what I take to be, a breathing tube. The anal orifice opens every now and again, and a bifid deep purple structure protrudes. From this a little fluid is first blown into a miniature bubble, then bursts and is dispersed as dew. The bifid organ is withdrawn and the anal scales closed. The structures (*a*), (*b*) and (*c*) are

portions of the larval test that protrude through the waxy encasement of the adult female.

SCALE INSECTS.

655. Mr. Green to whom I sent samples of this very interesting new tea pest, was good enough to send me some particulars, regarding the life of the insect. "A longitudinal section," he says, "through the insect would show the body completely incased by a waxy deposit. The spiracles, two on each side, open on to the under-surface, and their position is marked by opaque white wavy bands. After gestation the ventral parts of the body shrivel up and the cavity becomes filled with the eggs which in due time hatch out, the larvæ escaping from beneath the dead body of the parent."

Natural Enemies.

656. I may here add, by way of conclusion that the insect seemed badly parasitised, since many of the waxy encasements were perforated, no doubt owing to the escape of some ichneumon-fly that during its larval existence had lived on the scale-bug. The larvæ of a very small orange-red-coloured ladybird beetle (without any markings on its wing-cases) were also seen to be actively at work. These were very energetic little creatures, and from the formidable-looking hairs with which they were clothed on the back seemed as if they might also be poisons (*Conf. with Ind. Mus. Notes, Vol. IV., 27-28*). After the scale-bugs are killed or have died on one part of the bush the black fungus invades the shoots as well as the leaves, so that the advance of the pest from branch to branch and twig to twig may be traced by the black coating on the portions of the stem that have been abandoned.

Possibilities.

657. Depredations and Remedy.—It goes without saying that, were this lac-like scale-bug to become general, it might threaten the very existence of the tea plant. Hitherto it has appeared spasmodically, a clump of two or three bushes being killed, before it had been recognized. Fortunately it is easily seen, and its depredations so self-evident that the bushes are invariably cut down and destroyed—the pest being thereby in most cases stamped out. I have repeatedly said that it is impossible to foretell when a comparatively harmless accidental visitation of this kind, may suddenly assume gigantic proportions. It is the duty of the tea planter, therefore, to avoid the dangerous atitude of smiling at the idea of a bush which shows scale-bug being viewed as serious. The larvæ of these pests are so minute that they can be blown far and wide by the wind, or carried on the wings

CEROPLASTES FLORIDENSIS.

and feet of insects that come to feed on the sugary exudation. In one night from a nucleus of two or three bushes miles of tea may be invaded and the life sapped out of the bushes before the evil is récognized. The story of the Ceylon coffee-bug must never be lost sight of, nor its warning neglected. Many of the scale insects, like

Insecticides Useless.

Ceroplastes myricæ, are so protected by their waxy coating, or the hard shell-like structure of the scale, that insecticides cannot reach them. They may be mitigated or even killed by insecticides, however, after a careful study of their life histories has been made. The larvæ rapidly succumb to kerosine emulsion and a washing or spraying with the fluid, repeated at the periods of each fresh brood of larvæ, would in time no doubt eradicate the pest. The danger is that in the intervals of the insecticide treatment, swarms of the larvæ may have been allowed to escape. In cutting down the bushes the stroke of the axe may distribute the larvæ, and they may be shed over a large number of healthy bushes by the prunings being carried away by

Fire Preferable.

the coolies. It will, therefore, be seen that the treatment I have recommended, *viz.*, to fire the bushes, has much to be said in its favour. A distinct percentage of the bushes are saved, the pest is completely eradicated, especially if the one or two unaffected bushes around the diseased clump, are also burned.

88. (c) Ceroplastes cerifera, *Anderson.*

Indian Wax.

THE INDIAN WAX INSECT.

(Reg. No. 92.)

658. HISTORY.—The large irregularly shaped white waxy tubercles of this insect (often ¼ inch in size) are occasionally to be seen on tea, scattered here and there along the branches. These are so unlike insects that, unless the wax be dissolved off their bodies, they can hardly be recognized as such. This species nowhere occurs in sufficient abundance to justify its being classed as a tea pest, but it nevertheless is fairly common. I found it in a dozen gardens or so in Assam, and have samples sent me from Darjeeling.

89. (c) Ceroplastes floridensis, *Comst.*

(Reg. No. 93.)

659. HISTORY.—This curiously shaped pink-coloured wax insect is fairly common on tea in Assam and Darjeeling, and, Mr. Green tells me, it is frequent in Ceylon, "but not in injurious numbers." It will be generally seen on the upper surface of the leaves and in its young

state, when not much larger than the head of a pin, is a very pretty star-shaped object. SCALE INSECTS.

90. (a) Carteria decorella, *Mask.*

660. In the *Indian Museum Notes, Vol. IV., pp. 58-60,* particulars will be found of this insect which had been sent to the Indian Museum as "attacking tea and forest trees in Northern India." I did not find it on the tea in Assam nor in Kangra.

THYSANOPTERA.

LXV.—The Thrips.

661. It would seem probable that there are one or two species of this very remarkable assemblage of insects found in Assam as tea pests. I was unable to devote sufficient time to their study to enable me to learn any very definite particulars regarding them. They are very minute insects and are seen on the under sides of the leaves, especially on bushes overcrowded or under shade. The larvæ are pale lemon-green coloured and are less than $\frac{1}{16}$th of an inch in size. Small active longish creatures that run about all over the leaf, or take shelter alongside of the midribs or veins, on being disturbed. Occasionally they may be seen to have formed a minute web below which they repose. The antennæ are thrown back over the head and between the large crimson-coloured eyes. THRIPS.

The adult insects differ from the larvæ in being almost black, and in having two pairs of long narrow fimbriated wings one over the other. In other respects they are very similar to the larvæ.

662. The mouth might be described as a short sharp rigid proboscis composed of a pair of long bristle-like mandibles which they employ in perforating the leaf. It seems likely, however, that they should be regarded more as chewing the tissue, than as sucking the juice. This much, however, is certain, they cause large irregular patches of the leaf to become discoloured, and these sometimes even show through to the upper surfaces. On one or two occasions I found **Thrips** so plentiful, on a plot of tea described as "crinkly blight," as to suggest the desirability of special enquiry. It is well known that the European species of **Thrips** do the greatest possible harm to corn, potato and other crops. The larvæ push their way into the buds and destroy the grain. It thus seems possible that they may Depredations. Crinkly Blight.

Thysanoptera.

THRIPS. Stem distorted in Bud. *Conf. with para. 591.*

penetrate the buds of the tea and cause the loss of vigour and discolouration attributed, on the buds unfolding, to other insects such as the green-fly. I only offer this as a suggestion, however, and mainly in order, if possible, to arouse some attention to the subject of the forms of **Thrips** found on tea. I believe *it* highly probable that these minute pests may be found responsible for a greater amount of damage than we have any knowledge of at present.

WHITE-ANTS.

CHAPTER XIV.

PSEUDONEUROPTERA.

LXVI.—Termitidæ or White-ants.

663. In consequence of a letter received from the Secretary, Indian Tea Association (21st February 1896) the chapter on White-ants was prepared in advance of the rest of this report. Copies were issued to a selected number of tea planters, and in due course a few also found their way into the public press. In consequence, my opinions and suggestions on this much-debated subject, have been freely discussed. The remarks, which follow, may, therefore, be regarded as a revised edition. I may also add that, in connection with enquiries into the subject of Reha fibre, I had recently occasion to conduct an exploration of some of the districts of Northern Bengal and of Lower Assam. The opportunity thereby afforded was taken advantage of in verifying my previous observations, as also of testing the value of the numerous corrections and additional information that had been brought to light, through the private and public discussion of my views and recommendations. One practical result may be said to have been brought about, namely, the confirmation of the opinion I had ventured to urge, *viz.*, that we have more than one species of White-ant in India. During my more recent investigations I collected sufficient material to justify the statement being now put forward, that we have at least three, if not four, different species of Termites, and it seems possible, were India, as a whole, explored (from this standpoint), we might even be able to add a cipher to the figure named without overstating the specific diversities that exist under the generic name of "White-ants."

The Present Chapter a Revised Edition.

Practical Result.

664. The three or four forms recognized by me differ in structure, in habit, and in food. Unfortunately the state of the collections at the Indian Museum has deprived me of the opportunity of having my specimens compared with standard types and of assigning to them their scientific names, if such exist. Indeed remarkably few entomologists have studied the Termites, so that, for the present, I must content myself with such popular descriptions as I ventured to advance in the original version of this chapter. But let me urge that

Different Forms of White-ants.

Pseudoneuroptera (Termitidæ).

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Different Forms.

it is of vital importance to any progress in the practical aspects of the study of White-ants, *i.e.*, their eradication, that my statement be accepted as correct, *viz.*, that we have in India many forms of White-ant, some that will ordinarily eat only dead vegetable matter, and others that will attack and kill plants. The contradictions that one meets with in the literature of this subject proceed exclusively from the possibility being overlooked or ignored of there being White-ants and White-ants.

The three or four forms to which I more especially desire attention, as met with in Assam tea gardens, may, however, as a matter of convenience, be discussed under the only scientific name hitherto applied to them :—

WHITE ANT. *Conf. with para. 46 (16).*

91. (a) Termes taprobanes, *Wlk.*

THE CASTELLATED WHITE-ANT OF INDIA.

References.—*Report of Committee of Enquiry on the Ravages of White-ants in St. Helena, 1864; Scott in Journ. Agri.-Hort. Soc. Ind., Vol. III. (1871), pp. 42-47; Col. Money, Essay on Tea l. c., p. 219; D. D. Cunningham, Fungi in White-ant Hills, Journ. Agri.-Hort. Soc. Ind., IV., pp. 51-53, also Proc., 20th May 1875, xvii; Vol. IV, Ravages of, on Tea, Proc., 25th Nov. 1880, p. xxxvii; 22nd Dec. 1881, p. lxiii; Vol. VII., Proc., Woodrow on Corrosive Sublimate as a cure, 5th Jan. 1883; Proc., 31st Oct. 1884, p. cxi; Proc., 25th Nov. 1885, p. clxxxvii; Vol. VIII., Proc., 15th Sept. 1886, (Liotard on Neem Leaves as a cure), p lx; Cleghorn on White-ants, Vol. X., Proc., 29th May 1896, pp. 526-533; Tea Cyclopædia, 52-53; Green, Insect Pest of the Tea Plant, 93-98; Ind. Mus. Notes, Vol. I., 63-66 (Chutia Nagpur White-ants eat the roots), II., 172; III., 23; IV., 36, 102-104; Cotes, Insects and Mites, 46-48.*

Castellated White-ant Hives.

665. ***Different Forms.***—The common species of Bengal, we are told, bears the name of **Termes taprobanes,** *Wlk.* Viewed from a popular standpoint, and having regard more to their modes of life and methods of effecting destruction, than to their structural peculiarities, they would seem to be widely diversified. This will at once be exemplified by the mention of one circumstance. The castellated mud nests (often 5 to 10 feet in height) so commonly formed by the white-ants in Bengal, are not apparently constructed by the white-ants of several other provinces in India, and this fact is possibly accountable for by the supposition that some forms of white-ants live in cavernous excavations below, others in superficial structures above ground. Be that as it may, white-ants are known to abound in localities and positions where readily recognizable white-

White-ants.

ant nests are not found. In some cases they exist in vast colonies, in others as very small and isolated communities. How far these may be but stages in the life of one species is one of the obscure points that urgently demand solution.

WHITE-ANTS: FORMS OF.

According to my observations there are in Assam, for example, at least three, if not four, different forms of white-ants :—

1st.—A large species that constructs the immense (non-castellated) rounded ant-hills which, when levelled and brought under cultivation in the garden, are said to constitute barren patches. This might be regarded as the species that abounds in the jungles and forests, more particularly in association with the bamboo. It is often found in aggregations of hillocks, covering a more or less extensive area, and giving to the clearances of such tracts a curious undulated, almost warted appearance. This species does not appreciate association with man and dislikes the direct action of the sun. It consequently abandons its hillocks very rapidly on the forest being cleared for tea estates. It seems to live exclusively upon dead timber.

Round Hillocks in Jungles. *Conf. with paras. 680-696.*

2nd.—There is the village and cultivation-loving species that forms large castellated hillocks of mud. This will generally be found on clay soils, but only when above inundation level, hence it chooses the strips of high land around cultivation or on the homestead lands. This very possibly originates by a pair of winged ants (male and female) finding their way into the ground and existing for some time in subterranean caverns. But as the workers and soldiers of the new community (born from the eggs laid by the young queen) increase in number, the clayey ingredients of the soil are carried above ground, and the castellated hillock gradually formed. Passages under ground, that extend for marvellous distances, are also formed, but the combs and queen cells of the hive are, as a rule, placed above water level.

Castellated Hives in Fields. *Conf. with para. 167.*

There would, however, appear grounds for suspecting that the very similar-looking termite that invades human dwellings is in reality a distinct species from the castellated white-ant of cultivation. If they be the same, then it is a species that possesses the power of living under widely different conditions. For the present I accept the usual opinion that they are the same, and, therefore, this species may be said to live on dead wood, furniture, leather, paper, cloth—in

Pseudoneuroptera (Termitidæ).

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fact any dry animal or vegetable matter. But by encasing dead portions of plants with mud it not only eats these, but extends the destruction to living tissues. (*Reg. No. 127.*)

Surface Hives. *Conf. with page 367.*

3rd.—A rather long and very thin species of white-ant that constructs hives not larger, as a rule, than an ordinary foot-ball. These occur over grass lands, the hives or nests being found half under ground. They may be kicked out, and, while full of white-ants, will be found to have no deeper connection in the soil. Sometimes these hives may be seen to consist of reeds cut to a desired length, assorted parallel, then cemented together.* At other times the hive consists throughout of a black vegetable (non-earthy) substance, extremely hard, and so firmly compacted that the hives may be dashed on the ground with great force and still remain entire, or nearly so. The material of which they are constructed, it may be added, is very combustible. In a garden visited by me the other day, hives of this nature were being collected in scores daily, piled up in heaps and ignited—an excellent method of disposing of them.

Very Combustible.

When cut open they may contain male and female ants in the imperfect winged state, and neuters that are clearly the warriors and workers of the community. But though I broke open many hives, I never came across what I could regard as the queen of the community. So far as I have been able to ascertain, this species lives very largely on green vegetable matter. (*Reg. No. 129.*)

Under Ground Hives. *Conf. with page 367.*

4th.—Lastly, there is a small white-ant that lives under ground and particularly among the roots of bushes or within the decomposed branches above ground. This excavates oblong caverns that might be said to range from 1 foot to 2 or 3 feet in size. One might say that it would be next to impossible to dig a trench any-where in Assam without exposing several of these remarkable excavations, the interiors of which are always more or less filled up with a curiously reticulated structure that might be compared with the combs of a bee-hive. Similar combs exist in the castellated hives.

The "Raiders."

The form that I desire to draw attention to in this paragraph, might be designated the White-ant of Agriculture. Mr. Whigham has suggested for it the expressive name of the "Raider White-ant." It lives on the roots and lower shoots of living plants (on the tea, sugar-

* The fact of reeds being occasionally used shows that this is not the comb of the castellated white-ant, carried or washed to the surface of the ground.

cane, dall, gram, etc.) and, having made an entrance through the bark, it tunnels the roots and stems, unobserved for the most part, until by storms these are blown over and the existence of the pest revealed. (*Reg. No. 128.*) **WHITE-ANTS.**

666. Mr. E. E. Green in his interesting little book *The Insect Pests of the Tea Plant*, makes the remark : " I have recently received from different planting districts, several specimens of full-grown tea-stems completely hollowed out by a kind of white-ant. It is quite a distinct species from the common white-ant that attacks dead wood and sawn timber, being fully twice as large as the latter, and feeding upon green, instead of dead, wood. Of the species at present under notice, I have seen only the worker and soldier ants which were taken from the galleries excavated in the tea-stems."

Ceylon Species Living on Tea Bushes. *Conf. with page 368.*

It thus seems probable there may be many species of white-ant that would fall under the section of those that directly attack living plants, and are thus pests to agriculture. They may be said to agree on the main point of commencing their depredations, for the most part, on the roots or low down on the stem, or, at times higher up, by entering the stem through any openings in the bark that may be afforded them.

667. ***Conditions of an Ant Community.***—Each nest of white-ants is supposed to consist of a Queen-ant—an unwieldy creature that lays all the eggs of the community; Ant-neuters—the workers and soldiers; and wingless Larvæ both male and female. The last-mentioned become winged at a certain season of the year, and escaping from the nest in countless numbers and late in the afternoon, migrate from the ancestral dwelling. After a time these lose their wings and crawl away, in pairs (one male and one female), when certain of the females in time become queen-ants and give origin to new colonies. After impregnation, the abdomen increases vastly in size. An ordinary sized queen may be put at from 2 to 4 inches in length and fully half an inch in thickness. Mr. Green says that the queen may attain a length of 6 inches, and that she lives for several years.

Queen White-ants.

Neuters.

Male and Females.

Mr. J. Scott (quoting from Dallas) remarks that 80,000 eggs are sometimes laid by the queen in the course of twenty-four hours. Mr. Cleghorn remarks, that there are often two or sometimes even three queens, as also a masked (reserve) queen to each white-ant hive. The latter remains inactive within the royal cell until the

Number of Eggs Laid.

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Reserve Queens.

queen dies, out of season or from some unforeseen circumstance. The reserve queen seems to be derived from the annual swarm of winged insects, one being purposely carried to the royal cell for that purpose. It is not enough, therefore, to remove the queen, if the masked or reserve queen be left behind, she will immediately take the place of the queen, and continue the production of eggs. But if all the queens are destroyed the ant-hill is abandoned.

Distribution.

668. ***Distribution.***—There is hardly a situation from Cape Comorin to Kabul or from the tropical swamps of the plains to the temperate slopes of the Himálaya, where some species of termite is not met with. They may not be very abundant, but they are there. Afford them favourable conditions of food and leave them unmolested for a short time,—an inconceivably short time,—and they will multiply to a perfectly appalling extent and effect destruction in the least suspected positions. Most persons who have been stationed in districts badly affected by white-ants have witnessed beams, rafters, tables and other articles of house-hold furniture suddenly collapse, owing to the interiors of certain portions having been eaten away to a shell,—only just sufficient to carry the varnish or paint and to leave the article the external semblance of unimpaired strength. All unsuspected, these minute workers have carried destruction forward, devouring the drier and more central wood first, working, in other words, from the centre towards the circumference as they ascend from the damper to the drier extremity.

Mud-covered Ways.

669. ***Mud Encasements.***—Residents in the East are also familiar with the way white-ants encase with mud the stems and branches of trees, forming for themselves thereby covered ways that extend from the level of the ground often to the topmost bough. On these encrustations being removed the bark is seen to be pale-coloured, because of the superficial and drier layer having been eaten away. The white-ants do not, at first sight, appear to do any more serious injury to the barks of the trees, though it would be hard to believe that they are not injured by these coatings of mud. But if the white-ants don't eat the bark, the very natural question arises,—for what purpose do they form these mud-protected passages? (*Conf. with next page.*)

Subterranean Action.

It is a very generally accepted opinion that white-ants will not eat living and growing wood, and consequently that they do not kill, though perhaps they injure, living plants to some extent. This

WHITE-ANTS.

opinion, I feel satisfied, may be true of certain forms of white-ants, but is wholly untrue of others.

Influence on the Roots.

670. ***Influence on the Soil and Roots.***—There surely can be no doubt that white-ants, if permitted to take up their abode for some time in and among the roots of a plant, do incalculable harm. During their subterranean operations they remove the earth from below to form the mud encasements above ground and around the stem. Speaking of the tea bush, it is by no means an unusual state of affairs to find the plant growing as it were on the summit of a dome of hardened earth that surrounds the cavernous dwellings of its colony of termites. A section made by means of digging a trench, for 3 or 4 feet deep, across the space occupied by the bush and hard against the main stem, will reveal a most unhealthy state of affairs. At a depth varying from 1 to 3 feet a large central cavern will be found and fringing this numerous smaller ones. In fact an elaborate system of excavations will be revealed, and found to be occupied, like the Roman catacombs of old, by both the living and the dead. The roots that stretch across the larger caverns will be seen to have formed bark and to have assumed, to all intents and purposes, the condition of branches. The delicate absorbing fibrils will, moreover, be observed to have all disappeared, so that it needs little explanation to enforce the opinion that there has been a useless accumulation of plant energy below ground at the expense of leaf production above. But this is not all. A serious disturbance to the drainage of the soil and to its powers of retaining moisture has been effected by these unbidden colonists. When white-ants infest a neighbourhood, to any great extent, the soil is hardened, caked and dried to a degree that in hot weather is sure to prove disastrous to the crop and may ultimately even endanger the life of the older plants. On the other hand, during the rains, a surface wash takes place and an uneven percolation that may be noted to cause the subsidence of certain bushes. This necessarily means that the roots are torn from their positions and killed, food being thus provided for the white-ants and an entrance afforded them to the older woody portions. The presence of white-ant encasements on tea bushes should at once be regarded by the planter as giving warning of the necessity for immediate attention to that part of his estate.

Effect on Drainage.

Influence on the Soil.

Pseudoneuroptera (Termitidæ).

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They Attack Living Plants.

671. ***They Devour Living as well as Dead Wood.***—It is freely admitted that white-ants will attack the timber of very nearly every species of tree. Occasionally one hears of the great merit of this wood and that (particularly teak wood) as being proof against white-ants. And in some few instances this is doubtless true, though it would perhaps be safer to say, that the merit is but relative. In some cases life has hardly left the plant when it becomes attacked by these destructive creatures. In others, the timber has to be fairly well seasoned, and in still another sort has to be so old that its protective resin or other substance that the white-ants have an aversion to, has been dissipated. But be such immunity only comparative or complete, the main principle remains the same that white-ants will attack and devour practically any dead wood wherever it is left exposed to them and undisturbed for a short period.

Seasoned Wood.

672. But there are many directions in which these generalizations regarding white-ants and their depredations may be entirely upset. It is not uncommon to find the opinion advanced that white-ants can and do attack living plants. With that opinion I entirely concur. Let the mud encrustations of the bark be carefully removed and the ant road-ways followed upwards, until the stump is reached of a withered branch or the scar from which a branch has been wrenched, and the observer will witness how white-ants ultimately devour as they gradually kill plants. They will be seen to have eaten, or nearly so, the whole of the severed portions, but having found a passage through the external zone of living and growing structures, have begun to attack the fully-formed wood. They have deposited a dense coating of mud within the gaping wound and splintered timber with *a two-fold object of preventing the process of healing and of supplying an absorbent plaster that will suck the moisture from the wound and transmit it to the air.* In a very short time a layer of the wood will be thus killed and rapidly devoured. Layer upon layer follows until the stem is cut into very seriously, if not entirely severed. The circulation of the sap having been thus intercepted these mining engineers turn upwards into the dead and dying wood. Operating below ground and thereby diminishing the supply of moisture, while availing themselves at the same time of every abrasion or injury to the stem or its branches above ground, is it to be wondered at that the process of destruction, though it may be almost imperceptible, is

Mode of Attack.

Object of Mud Deposits.

Diminish Water-supply.

nevertheless certain in its ultimate result! But let it be clearly observed, most white-ants live mainly on wood, not on green vegetable matter. The majority will not, as a rule, kill the green sapling, nor attempt to eat their way through the external zone of green wood of healthy plants. They will preferentially attack plants that contain a central axis of fairly well-formed wood, and may require even then the aid of some accidental agent to give them access to the wood. By their action below ground they dry the roots, the bark of which is much thinner and not permeated to the same extent by sap as the bark of the stem and its branches. The species that attack seedlings or small woody shrubs generally commence operations from below. Those that live on trees, on the other hand, start their depredations, as a rule, above. The result is the same in both cases, the wood is first dried and killed, then devoured.

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Prefer Mature Wood of Stem.

It is First Dried, and Killed. Then Devoured.

673. ***Practical Considerations.***—The story of the manner in which white-ants can and do attack and kill plants and thereafter eat the woody portions of their stems and branches, is true in a thousand and one modifications. Let a boring insect make an entrance into the stem, branch or root, and white-ants will soon follow. Let the planter prune ruthlessly, leaving large surfaces, or snags, or torn portions of wood exposed to the action of the air, and if white-ants are about they will rapidly cover up his slovenly work with a shroud of mud. The vigorous efforts of the living bark may, however, more or less completely embrace and enclose the scar, but sooner or later the plant will give clear indications of its kankerous state by ceasing to be productive. The bark may appear quite entire and comparatively healthy. On being probed, however, it will suddenly snap asunder and reveal a mass of mud within a shell of living tissue.

Boring Insects.

Influence of Pruning.

Hollow Stems.

674. These are no imaginary pictures. I have already alluded to this subject under Pruning. Hardly a tea garden exists in which the evil effects of pruning followed, it may be, by the depredations of white-ants cannot be seen. Bushes will be found here and there all over most estates, in which the lower half of the stem is a portion of an old shell, perhaps not more than half an inch in thickness and 2 inches in breadth which carries on its apex, a sickly and distorted dome of useless and unproductive branches. In other words, it is no uncommon occurrence to find the lower half of the

Tea Bushes on Stilts. *Conf. with para. 220.*

Growing Shell.

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Rotten Stems.

stem gnarled and rotten with numerous mud stumps representing abortive branches or having one side only alive, the place of the other being taken by a great open scar, perhaps mud encased and infested with white-ants.

Whole-sale Destruction.

Young Tea Attacked.

675. This is what might be described as the normal condition of a large percentage of the bushes in many old gardens. But one not infrequently hears of wholesale destruction where both young and old tea have suffered, more especially the former. During my tour in Assam I was shown over not a few gardens where a high percentage of young tea had the stems encased with white-ant mud and where very many plants were being directly attacked by the insects. Through the kindness of Mr. W. H. C. Whigham, I have on my table samples of tea three to tour years old, well formed and healthy looking, and which had, I am told, attained a height of 6 to 8 feet. In many of these samples the stems have been cut almost square across, at a height of about 3 to 6 inches above ground. In other cases the stems have been furrowed and excavated to such an extent as of necessity to kill the plants. And this has beyond doubt been accomplished by white-ants upon otherwise healthy plants.

Stems Cut Across.

Mr. Whigham has described very clearly the manner in which in many cases the white-ants had effected an entrance into the well-formed central wood of his samples, and his views corroborate my own observations. He says:—

How this is Accomplished

"The lowest branch of the tree, some 2 or 3 inches above the ground and frequently springing from the surface of the soil, is injured in some way at the point it leaves the main stem, by some borer or other pest. It then drops, withers and finally falls off from the tree. White-ants (or what we commonly accept as being white-ants) have by this time effected an entrance into the tea bush. Working upwards, eating out the centre, and leaving the stem hollow. The first storm of wind breaks off the tree just above the ground."

Further on Mr. Whigham adds: "I am unable to state what causes the low lateral branches first to droop and then fall off from the tree. I can discover no borer or other insect, but it is possible some such pest may, in the first instance, show the way for the white-ants to follow. The damage is most apparent from August to December, when, usually speaking, white-ants are most abundant and visible. It being too dry at present (February) for these pests to continue their ravages

amongst the tea bushes. I have never seen any clearance so devastated as this one has been from what, after a long experience of Assam and Cachar, I should name to be white-ants." Speaking on the subject of the season of the year when ants are worst, Colonel Money (*Cultivation and Manufacture of Tea, p. 90*) says: "From the close of the rains to the cold weather is the worst time for white-ants, and the time the planter should guard particularly against their ravages. At that time if he examines his trees closely, he will very likely find white-ants on a quarter of the whole."

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Season When Most Severe.

676. ***Opinions of Authors and Practical Planters.***—A writer in the *Tea Cyclopædia* says:—"I had a belief that white-ants only attack old gardens which are not kept clean, and where dead wood is allowed to rot; but it is not so. I see that the white-ants will infest young and old gardens equally, though every care be taken to keep them free from decayed timber. Our garden is only 2½ years old, and the best block is suffering from the depredations of the white-ants. It is heart-rending to see a young thriving bush, which showed no symptoms of decay in the evening, lying prostrate on the ground next morning, with a hole in the trunk an inch long and ¼ inch in diameter. I consulted several of my brother planters, old and experienced, in Chittagong, and they all advised me to keep up constant hoeing, but it had no effect. I next tried kerosine oil, and painted every bush in the block with a brush, but it was of no avail."

Opinions of Authors.

Kerosine oil useless.

677. Messrs. Octavius Steel & Co. placed before the Agri.-Horticultural Society a letter from one of their managers complaining of the ravages of while-ants.

678. Mr. Driver, of Lohardugga, complained of the depredations of white-ants on tea. In Chota Nagpur they are found to attack the roots of many agricultural crops.

679. During my Assam explorations I satisfied myself that, although the common white-ant usually attacks the upper parts of the stem, in the manner already detailed, another form—a smaller insect—attacks the roots of recently transplanted seedlings and the plants in nursery. The external mud encasement around the lower portion of the stem (seen in the latter case) is intended very possibly to suck the sap from the bark and dry the wood, thus preparing the way for an advance from the roots to the stem. That a system of sucking

Mud Encasements on Seedlings.

Pseudoneuroptera (Termitidæ).

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Objects of.

moisture, both from the plant and the soil, is a governing principle, so to speak in their methods of destruction, must be evident to every person who has given this subject any degree of consideration. Mr. Whigham put this matter pointedly to me the other day, during a march through some portions of the Hautley Estate. He took me to a castellated hillock, and informed me that every second or third day he had ordered the top to be knocked off. Time after time it had been replaced. The soil for months past, Mr. Whigham explained, had been parched, not a drop of moisture to be had anywhere for the poor tea bushes, and yet these little pests seem to find the moisture necessary for their building operations. The explanation no doubt is, that they gradually suck the moisture from the roots, from the soil, and even from the moist bark, below their mud encasements, and also utilise the dew found on the leaves. Wherever obtained, water is employed in the repairs or construction of the castellated hillocks or mud encasements, and exposed to the air is soon dissipated with the not unnatural result that the soil is gradually parched to an injurious extent, and in time the plants are killed.

From Whence is the Moisture Obtained?

White-ants in Sylhet. *Conf. with paras. 665 (1), 696.*

680. In a letter, which I have had the pleasure to receive through the Indian Tea Association, Mr. James Hall, of the South Sylhet Tea Company, writes, "I am certain that the mound-forming ant does little or no harm to tea. There are in this valley gardens covered with ant-hills, and these gardens, as a rule, have not suffered from the ravages of the white-ants. There are other gardens where there are almost no ant-hills, and on these gardens the bushes were, for the first year or two, cut down by thousands. The amount of damage done by white-ants depends entirely on the nature of the soil. On light soils, more especially if *telah* or plateau, they are usually most destructive. The ant-hills on these soils seem to me to be different from those made by the jungly or larger white-ant. They are usually not so high. If Dr. Watt cares to visit Sylhet, he will see gardens almost without ant-hills, that have lost 10 per cent. plants from the ravages of white-ants, and others, where ant-hills are very plentiful, that have hardly lost a plant."

Influence of Soil.

681. In another letter forwarded to me, Mr. E. Scarth, Superintendent of Attaree Khat Tea Company, says, "The ant which, so far as my experience goes, is to be feared as doing damage to tea plants, is the small species that lives under ground in oblong caverns: the large

White-ants.

white-ant that raises large hillocks does comparatively little damage, and if the queen ant is dug out from the hillocks, the rest of the ants leave it. I have levelled many of these deserted hillocks and planted them out with fair success." "It is the small white-ant which is our enemy, and a good trench hoeing or forking in autumn should, I consider, be the best remedy.

WHITE ANTS.

Hillocks Planted Out.

682. Recently I have had the pleasure to receive, through Messrs. Balmer, Lawrie & Co., a most excellent series of examples of white-ant-destroyed tea bushes. The ants supplied along with these specimens as having been picked out of the mud deposits within the stems, proved to be the fourth species in the above enumeration. Mr. F. E. Winsland, in his letter that accompanied these specimens, made some useful observations. He proposed to collar prune the affected plot, to paint the exposed sections of the stems with Stockholm tar, and, in order to catch the white-ants, he intended to fix in the ground around the stump of each bush three stems of *tamal* grass. On these becoming full of ants he proposed to collect and have them destroyed. I may remark that the method of using food traps for pests is often a dangerous one, since instead of catching what exists the supply of food furnished may cause an increase in the numbers of the pest. The treatment proposed by Mr. Winsland is, however, the only satisfactory one with old gardens badly affected by white-ants, namely, to collar prune. Their food is thereby completely removed, and the exposure of the soil to the sun, as a rule, kills or drives away the ants. Since my answer to Mr. Winsland's letter gives certain particulars that may be of value, it will be found below, published as an appendix to this chapter.

Correspondence, see Appendix, pp. 366-369.

Food Traps.

If Badly Injured Collar Prune.

683. Mr. G. E. Noad, Manager, Cherrie Valley Tea Company, Kumbhir, Cachar, in a letter to the Indian Tea Association, says that, "White-ants do a terrible lot of damage to any bushes that have to be cut down." A writer in *The Indian Agriculturist* says, "Some lands are infested by these pests; other land, again, is quite free from them."

White-ants in Cachar.

684. Having furnished in the above paragraphs information recently to hand, corroborative in certain directions of the remarks originally offered by me, in the first edition of this chapter, it may be as well if I give here certain opinions that are opposed to my views:—

Action on Living Plants:

685. The late Mr. J. Scott, formerly Curator of the Calcutta Botanic Gardens, in a most instructive and thoughtful paper entitled

Stated to be a Mistaken Notion.

Pseudoneuroptera (Termitidæ).

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"Notes on Horticulture in Bengal," says of white-ants—"There is a prevalent, but certainly a mistaken, notion, that they also devour the living parts of plants. Cuttings of Sugar-cane, as also those of many of our garden plants, are said to be especially liable to their attacks, and I have thus been induced to bestow considerable attention on their habits. In sugar-cane cuttings, I find that diseased portions are very quickly attacked by the white-ants, and scooped clearly out to the very surface of the living part: further gnawing then ceases, though the insects remain to sip the exuding juices and this, as frequently happens—when the diseased surface is large—so weakens the cutting that it is unable to afford the necessary nourishment for the young offshoots, until they are self-sustaining, and thus all die, and of course become the prey of the white-ants. It is doubtless from examination of the cuttings of these stages only that they have been falsely accredited with their complete destruction. Though I am thus certainly of opinion that the white-ants do not eat the living parts of the cane-cuttings, I nevertheless believe that they cause a certain amount of damage to them. This they effect by gnawing off the dead and dry parts, thereby exposing a fresh and living surface, from which they continue to draw the thin freely exuding sap, and thus weaken and intensify the disease in a manner which might have occurred naturally. I thus think that of two similarly and partially diseased canes, of which one is free from, the other attacked by, white-ants, the latter will be less liable to resist the further inroads of the disease than the former. For the same reasons they are likely to cause injury to cuttings of our ordinary flowering plants; but this can only occur through neglect of the *mali*. To attract the white-ants, there must needs be a partially dead cutting in the pot on which they, in the first instance, ensconce themselves; thence extending their excavations they come in contact with, and perhaps remove the soil from the cicatrising base of other cuttings, thereby checking mayhap killing them, in thus withdrawing their supply of moisture. In these respects, then, I admit that white-ants may, and I believe do, cause mischief to cultivators; but that they really devour the living parts of plants is, I believe, wholly unfounded."

Suck the Juice.

Cuttings Killed.

Dead and Dry Parts Eaten: Fresh Living Surfaces Exposed.

They Remove Earth from Base of Cuttings.

Do Much Mischief.

686. If the opening sentence and the concluding expression of personal opinion were removed from the above passage, I should have no objection to its appearing as an opinion supporting powerfully my con-

tention that white-ants kill tissues and, in time, whole plants, and, when so killed, devour them. It seems to me to beg the question to say that they do not eat living and growing tissues. If they possess the power of slowly killing plants the practical result is the same to the tea cultivator as if they ate them alive.

WHITE-ANTS. **Kill First Then Eat.**

687. So, in the same way, much has been said on the theme that white-ants are only secondary agents, following on the path of a grub that eats the roots, or of a borer that works in the stem. That contention (which I admit is doubtless true in some instances) is, I venture to think, inadmissible as a general guiding principle in the practical consideration of white-ants as a pest to crops. Dysentery may be a disease that very frequently follows some other ailment, but it is an aspect of the patient's case that must be dealt with promptly. To argue that white-ants may have been unjustly accused of being a primary pest, is dangerous. Mr. Cleghorn concludes an interesting paper on white-ants (in which the contention prevails that they are only secondary agencies in the destruction of crops) by the following passage which discusses the condition of affairs found in three diseased **Araucaria** trees in the Agri.-Horticultural Society's Garden :—" At the base of each **Araucaria,** from ten to thirty grubs were found. They had bored into, and through, the stem, leaving a lot of dead wood on each side of the borings, and demolishing the pith; White-ants had thus gained an entrance to the pith which they had destroyed, in one case to a height of 18 feet, and in the others to 13 feet and 17 feet respectively." It was unfortunate that Mr. Cleghorn did not think of telling us what proportion of these destructions had been primarily accomplished by the grubs, and how much should be laid to the charge of the secondary agents of destruction.

Affirmed to be Secondary Agents.

Unjustly Accused of being Primary Agents.

The Stem Eaten for 18 feet.

Conf. with page 368.

688. Mr. J. B., of . . . in a private letter dated May 25th, 1896, (which I take the liberty to publish since it contains much of public interest, though I suppress the names of the persons concerned), in this connection, while commenting on the advanced proof of this chapter, (sent to him for opinion), says :—" Mr. J. H., General Superintendent of the . . . Company, and Mr. J. L., Superintendent of . . . . . , agree with me that white-ants will not attack a healthy tea bush; if they did, I am afraid there would not be a tea bush left in Assam. I have seen healthy tea bushes thriving in the middle of an ant's nest."

Will not Attack Healthy Bushes.

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All Old Bushes are consequently Unhealthy.

"You have a very strong case, I own, at Hautley garden, but the general opinion is that there must be some other cause, the bushes being sickly. White-ants then come in for the final destruction. I do not suppose a single old tea bush is pruned down, or what we now call collar pruned, without being found to be attacked by white-ants in the centre of the old and decayed stump. You pointed this out yourself to me, and my experience is that in all cases of collar pruning the centre of the original stump gradually decays, and is eaten away by white-ants; while from the outside of the stump (very often under ground) new shoots start, the nucleus of fine and healthy bushes. In collar pruned tea, one is fortunate if one does not lose more than from 5 to 10 per cent. of the bushes, but we are well rid of these, for they are usually the sickly ones that cannot stand a pruning of such a drastic nature, and the only remedy is to fill the vacancies up with young plants."

Collar-pruning Favours White-ants.

A Percentage only Unhealthy.

Chances Given to White-ants.

"I mention this simply to show what a chance we give to white-ants to destroy our tea wholesale, but they cannot do it."

Mr. B. then concludes his letter by the following sentences: "I would ask a simple question and it is this: Has any planter, by the application of any of the emulsions you name, brought a sickly bush round (*i.e.*, a bush to all appearance being destroyed by ants); the ants may be destroyed, but has that bush ultimately recovered and become vigorous?"

Several Forms of White-ants.

One can Attack Seedlings, the Other Decayed Wood.

689. I would venture to point out that the above criticism has overlooked, as it seems to me, a point I have laid stress upon, namely, that there are several forms or species of white-ant, one that will distinctly attack young seedlings, and another that has not the power to do so, but commences its operations on dead wood. I might mention a score of gardens in Assam where I found the former white-ant attacking seedlings direct, and my correspondent may certainly congratulate himself that it has not so far been his misfortune to make their acquaintance. The other form may, however, ascend the stem of old plants, and, if it finds wood anywhere exposed, will devour that, and, having thus found its way into the stem, will eat down the centre until in time it produces the condition Mr. B. has so vigorously described. The answer to the question put above has certainly to be given in the negative, for, if badly attacked, I believe there is no cure but collar pruning. It may be that white-ants find sickly plants more

easily preyed upon than healthy ones. The diseases they were suffering from, however, were possibly curable, whereas, once the centre of the stem has been eaten out, there is no cure. It is not cure, therefore, that I have tried to advocate but improvements in cultivation as methods of prevention and also the eradication of the pest if that be possible. But I should like to ask if the decomposition of the centre of the stem is a necessary and unavoidable consequence of age and whether only old trees have their stems so decomposed? If that be so, then white-ants are doubtless fulfilling a provision of nature in destroying what is useless. In my opinion, however, white-ants are very much more frequently a cause, than a consequence, of the decomposition of the stem.

WHITE ANTS.

Prevention rather than Cure.

Cause more than Consequence of Stem Decomposition.

690. ***White-ants Attacking Mango Seedlings.***—Speaking of the form of white-ant that attacks the roots of seedlings, though a digression somewhat from a report on the pests of the tea plant, I may illustrate my contention by a passage or two from a most instructive paper recently to hand from the Settlement Officer, Balaghat, in the Central Provinces:—"White-ants," that Officer writes, "are especially fond of young mango trees. In some villages repeated efforts to make a mango grove have failed, on account of the roots of the young trees being attacked by white-ants. I once doubted this fact and was disposed to believe that in these villages the people were unusually negligent in watering the saplings." He then goes on to narrate how he tried to raise some mangoes near his own bungalow, but "a number of the saplings died, they being in most cases attacked by white-ants. I have dug up three of the trees in different stages of the white-ant disease. One of the plants was almost dead, and it would have been difficult to prove that the white-ants were not innocent scavengers removing useless dry wood. Another tree was half-dead, and the theory that exonerates the white-ant from the charge of devouring living timber, could only be maintained by crediting the termite with a marvellously accurate prophetic instinct, that told the scavenger which of the trees were already doomed to die, and might be removed as useless, for the tree was not yet dead, but only likely to die shortly. In the third case, the tree still looked quite green save for a suspicion of unhealthiness about some of its leaves. On digging it up I found that its roots had been eaten through in places by white-ants, and that a detachment of the voracious termites was

Roots of Seedlings Attacked.

Scavengers Removing what is Useless.

Prophetic Instinct.

Green Wood Eaten.

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Field Crops Devoured.

actually pushing its way up the heart of the sapling eating its path through perfectly good juicy wood." "I have found fields of *tur* (Cajanus indicus) in which a number of the plants have withered owing to the roots being eaten by white-ants, and in gram fields I have had similar damage pointed out to me."

But having given the above review of information brought to light, more or less, as the result of the publicity given to the first edition of this chapter, I may return to the original text.

Saplings Cut Square Across also Furrowed.

691. ***Death of Twigs Low Down on the Stem.***—As already stated, there is no doubt Mr. Whigham's specimens have been cut across and furrowed by white-ants, and although, he says, he has been unable to solve the problem of how the lower lateral branches have been killed, he is very possibly correct in believing that it was through the death of such lateral branches that the white-ants found an entrance to the wood of the main stem provided they did not enter by the roots.

Ruthless Destruction of Branches.

Where the destruction has not been preceded by a borer or other parasite, nor has been caused by defective pruning, it may be due to the branches being broken, or simply by being imbedded during deep hoeing. But there are many circumstances that might each contribute to injure the lower branches. The point of importance, that it is here desired to urge, is that, without some external abrasion or injury, giving access to the central wood, white-ants are, as a rule, unable to accomplish their mission of destruction.

External Abrasion Necessary.

The risk the lower branches are exposed to during heavy hoeing is, however, very great, and *where white-ants are known to abound,* it should be a point for careful study whether it would not be the wiser course to remove all the lower branches at an early stage and encourage the formation of only one or at most two or three main stems with no branchlets for some distance above ground.

692. ***Best Time for First Pruning.***—A question raised by Mr. Whigham has been partly disposed of by the remarks already made, but it may be emphasised here. He says:—

"The full-grown bushes appear to be selected in preference to the younger and smaller plants. Do you suppose, as the bushes grow older, they develop something peculiarly favourable in the wood or sap for the pests to feed on? Would earlier pruning, say after the plants have been a year in position (cutting down to 6 or 9 inches) strengthen the plants?"

693. The answer to the former question must of course be that it is not a sap favourable or otherwise that white-ants desire, but the absence of sap. The central wood of a growing plant after a certain age, might almost be described as dead. It is not at any rate actively living and growing, but is timber more or less completely formed, and the older it becomes the more true is this observation. Fully developed wood is the food that white-ants are partial to, and such has only to be exposed to them to be devoured. The best protection to the stem, far and away superior to all insecticides, is a healthy and entire bark with a vigorous sap-wood.

WHITE-ANTS. Seasoned Wood Preferred.

Heart Wood is Practically Dead.

694. The answer to Mr. Whigham's second question might be in the affirmative, but the point is one that should be carefully determined by practical tests. There would seem to me no doubt that the process of pruning, when seedlings are three or four years old, exposes them, in certain districts at all events, to a far greater extent to the attacks of white-ants, than pruning accomplished at an earlier stage. But on general principles of tea cultivation, I have already recommended a fairly early period being fixed for the first heavy pruning, say, not later than one year. I have in fact so fully expressed my views on the subject of pruning, that it would be superfluous to repeat them here. I believe bad pruning to be the chief reason why the centre wood of old bushes is so very frequently rotten and white-ant infested. Far from being prepared to accept the state of affairs that prevails, as a necessary condition of age, I am confident it is largely preventable.

Pruning Seedlings Early.

Action of White-ants Preventable.

695. But the first step in that direction is the recognition of white-ants, each and every form of them, as injurious to tea. I have already stated that I do not believe the castellated form ever directly attacks and kills bushes, but I am abundantly satisfied that, even it is capable of the greatest possible mischief. It will at once attack any dead wood that may be on a tea bush. Once any species of white-ant deposits its mud encasement on dead wood, it eats slowly, and, as it progresses, the mud sucks out the moisture and disseminates that to the air, so that, deprived of its sap, layer upon layer, is killed and eaten. White-ants thus work into the very heart-wood and run up or down the stems and even along the roots, with a natural enough result. The bush becomes unproductive, and is pronounced old and diseased. White-ants are an ever-present danger that have aged prematurely many gardens, and are to a

Mud Encasements Suck out the Sap.

Gardens Prematurely Aged by White-ants.

Pseudoneuroptera (Termitidæ).

TERMES TAPROBANES.

perfectly alarming extent lowering the productive capabilities, I fear I am correct in saying, of most gardens in Assam. All the while they are but too frequently looked upon as necessary evils, harmless little creatures that have by some misguided people been falsely accused of eating living plants, while they only kill them first and eat them afterwards.

Hillock Forming Ants.

Conf. with 1st form, Paras. 665, 680.

696. ***Harbouring White-ants.***—Having thus briefly dealt with the manner in which white-ants attack living plants and the destruction they are capable of effecting, I turn now to the circumstances that may be regarded as harbouring these undoubtedly dangerous pests. The very foremost consideration should be given to the removal, as far as possible, of all ant-hills or nests. Many planters prefer, so they told me, to leave these alone, because of the all but universally admitted opinion that tea will not grow on the top of ant-hills, and that the area of sterility is greatly extended by levelling them down and scattering the earth over the surrounding land. While in Assam, I examined many large rounded mounds (some of them with tea growing on the top) which in every case I was told were "old ant-hills," but I did not come across one in which I found ants, nor one of this class described as a new ant-hill. While not questioning the accuracy of the opinion given me regarding these mounds, nor even that it might be possible to find many that contained countless myriads of ants, I simply affirm that I did not come across one *within the limits of a tea garden* that was inhabited, or seemed inhabited, by ants. I found many similar round ant-hillocks in the forests and jungles, all inhabited by the ant. So, again, the castellated ant-hillock is by no means common in tea gardens, though occasionally one may be seen on the roadsides or commencing to grow up around a bush. The contradictory opinions that one obtains as to the sterility or fertility of ant-hillocks may, as it seems to me, proceed from the two kinds of mounds, above indicated, being widely different. At all events my observations led me distinctly to the conclusion that the white-ants of the jungles love neither the jungle clearances, accomplished by the planter, nor the object of his solicitude.

697. This is, however, a point regarding which there should be no uncertainty. Very little study would suffice to remove all doubts. Clearly if the rounded mound-forming ant be a distinct species, and

one that is comparatively not injurious to the tea, but dies out after it has been exposed for a few years to the full action of light, there would be little or nothing gained by levelling the mounds. Better leave them alone for a few years until, by the growth of weeds, they had been shown to be converted into fertile soil. But if I am wrong in this suggestion and they are, as some planters believe, great fatherlands of this tea pest, the sooner they are levelled, dug out and the queen ants destroyed the better. Whatever present expense this may entail, that would be preferable to increasing the danger hereafter of white-ants. WHITE-ANTS.

698. But with the subterranean white-ant, I shall go further. Wherever that insect may be seen on the surface soil or lining the tea bushes or other objects with mud, to an abnormal extent, I should have them traced out, if possible their cavern discovered, and the comb-like structure and the queen ant destroyed. I am fully aware that in many estates this might mean digging holes 2 or 3 feet in depth every few yards. But supposing it did, a process of attempted eradication, however incomplete, would be distinctly more profitable than the losses at present sustained. The simple fact of disturbing the white-ants would be beneficial, and an occasional deep hoeing, such as I have mentioned, at isolated points over an estate, would have other advantages. By leaving white-ants undisturbed, the planter is directly harbouring one of his most formidable enemies. **Eradication.**

699. ***Burying Wood, Prunings, etc.***—During the clearance of new land nothing could be more pernicious than the habit of burying stumps of trees, branches, roots, etc., in the soil. Food is thereby provided all over the future estate for great colonies of white-ants which, when their store of food, thus provided by the planter, gets exhausted, will lose no opportunity to attack the tea. This argument holds good with even greater force to the still more pernicious habit of burying the prunings from the tea plant itself. This subject will be found fully dealt with in another chapter, and it is only here alluded to as having a direct bearing on the question of white-ants. **Burying Prunings.** *Conf. with para. 170.*

700. All woody structures, whether from the jungle clearances or the subsequent tea prunings, should be burned. In that form they are valuable, while as wood they are dangerous. Mr. Whigham has asked the question whether the stakes employed in planting out tea tend to introduce and distribute the pest of white-ants. My answer is **Burning Prunings.**

Pseudoneuroptera (Termitidæ).

TERMES TAPROBANES: REMEDY.

Queen Ant Killed.

can of the infusion, poured into the holes of a fairly well-established nest, sufficed. Shortly after being treated in this manner he had the nest dug out and found the queen ant and all the others dead. This result seems, therefore, fairly hopeful. It might be tried on a more extended scale and the results reported. I am not, however, very sanguine of the value of any insecticide in the eradication of this pest. Thorough and cleanly agriculture should in the long run prove both more economical and more effectual. White-ants should, in other words, be dug out, the roots of the bushes freed from their excavations and hives, and the stems and branches at the same have all mud encrustations removed.

Neem Leaves

705. In the Journal of the Agri.-Horticultural Society Mr. Liotard announced that he found a few leaves of the *neem* tree, buried in the ground, drove away white-ants from his rose bushes. The Assam *bakhain* no doubt might be used as a substitute, and from experiments performed some years ago I should be disposed to believe the insect may have an aversion to that substance. Many writers have affirmed that the fresh juice of the leaves of the American Aloe, poured on to a badly-affected plot of land, will drive away white-ants.

706. The Commissioners appointed in St. Helena, to enquire into the subject of white-ants, experimented with some sixteen different substances sent to them from all parts of the tropical world, as being useful preventions or cures against the depredations of white-ants. Some of these may be here alluded to :—Mr. Robertson, of Ceylon, recommended sugar mixed with arsenic: another Ceylon correspondent mentioned arsenic, creosote, and bichloride of mercury. Mr. Davies, of Madras, recommended arsenic, aloes and chunam soap. Many writers spoke favourably of tobacco juice and common salt mixed, but the report may be said to have pronounced that each and every method had been tried, and none proved effectual either to check the ravages of the scourge or to protect woodwork from destruction.

Preventive Paint.

707. *Useful Preventive.*—While travelling in Kattiawar some short time ago, my attention was directed to a habit that prevails in the Gondal State of painting the stems of trees to a height of 3 feet above ground with a red-looking substance. It was impossible to march through the State and not be struck with these red bands. I enquired the reason. In reply, I was asked to see whether any of

the trees so painted were attacked with white-ants. Throughout the States of Kattiawar white-ants are a positive calamity as they attack and practically destroy whole avenues of trees. I found the red paint, whatever it consisted of, was an effectual protection. In no instance did I discover trees encased with mud where the red ring was fairly visible. I enquired into the nature of the preparation used, and the particulars I obtained were published shortly after in a paper on the subject of *Ál* dye (**Morinda citrifolia**, *Agricultural Ledger No. 9 of 1895, pages 3-6*), because *ál* was said to be the colour-imparting ingredient. The following passages may be here republished from that paper:—

WHITE-ANTS: REMEDY.

Trees Painted Red for Three feet of Stem.

Paint used against White-ants.

Preservation in Gondal State from White-ants.

708. "During a brief visit to the Native State of Gondal, the writer recently gave this subject considerable attention. There seemed to be no doubt that His Highness the Takore Sahib, by his enlightened action in this matter, had effected a radical improvement. The trees throughout his State were all painted as described above, and not a single tree could be found that showed the mud encasements so characteristic of the presence of white-ants. And very possibly, as a consequence of the care bestowed on these trees, they were healthy and vigorous, while those in neighbouring States were sickly and badly attacked with white-ants. In consequence of these observations the writer asked for information as to the composition of the paint which had been used. He was informed that the red colour was merely to indicate the fact that the trees had been painted, and that it was for the most part red ochre, but might also be made of the refuse of the Ál Dye works. The useful ingredients were said to be as follows:—

Preventive Paint. *Conf. with para. 998.*

1 part *dekamali* gum (the resin of **Gardenia gummifera** or **G. lucida**).
2 parts asafœtida or *hingra*.
2 parts bazar aloes or *musubar*.
2 parts castor-oil cake.

These are well pounded, mixed and kept in water for about a fortnight. When thoroughly united, and what may be called decomposed, into a thickened compound, water is added in order to bring to the consistency of paint, and the colouring matter then added.

Pseudoneuroptera (Termitidæ).

TERMES TAPROBANES.

in *The Agricultural Ledger* (No. 9 of 1895). The trees I selected were two that had ant heaps at the base and had been covered the previous season with mud encasements. Since the application of the preventive the trees have been free from White-ants. The trees still show marks of the preparation."

From Assistant Secretary, Indian Tea Association, Royal Exchange Building, Calcutta, 29th April 1897. No. 166-O. To (All Members of the Association).

White-ants in Tea Gardens.

DEAR SIRS,—I am directed by the Committee to forward, for your information, printed copy of a letter, dated 19th April 1897, from Messrs. Balmer, Lawrie & Co., together with copy of a letter from Dr. Watt, C.I.E., on the above subject.

From Messrs. Balmer, Lawrie & Co., 103, Clive Street, Calcutta, 19th April 1897. The Secretary, Indian Tea Association, Calcutta.

DEAR SIR,—We have been taking a particular interest in the causes and effects of the *White-ants* and their depredations, and the writer, on a visit to Assam last November-December, went rather fully into the matter, which has brought about some interesting correspondence. The enclosed copy of a letter received from Dr. Watt, dated 13th instant, being of considerable value in suggesting certain remedies to try and eradicate this pest. We have much pleasure in making the information over to the Association, and trust that the Committee will see their way to circulating a copy of the letter to all the Members of the Association.

We should also be pleased if you will comply with his wishes, and send him a few copies when printed.

No. $\frac{815}{229}$ A., Calcutta, the 13th April 1897. From George Watt, Esq., M.B., C.M., C.I.E., etc., Reporter on Economic Products to the Government of India. To Messrs. Balmer, Lawrie & Co., 103, Clive Street, Calcutta.

Collections, of White-ants.

GENTLEMEN,—I have to acknowledge yours of the 29th March as also the box of specimens of tea bushes attacked by white-ants. I am afraid you will hardly regard the matter as one for congratulation, when I inform you, the samples supplied are the best for Museum purposes I have ever seen. I am sorry your correspondent was not as successful in the collection of the insect. To name the species, it is necessary to be supplied with a larger number, including the queen, in order to make sure that we have a complete series of all the forms that live within the colony, and collectively constitute the species. As you are aware, each species of white-ant has several forms—queens, out-door workers, soldiers, domestic or household ants, etc. Now, we can only be sure of species (A) as

distinct from species (B), when we are able to examine and compare, side by side, the queens, out-door workers, soldiers, etc., etc., of each species. So far as I can see, the insect supplied is the small white-ant described by me in my note as not forming a castellated hive. I shall be obliged by your asking Mr. Winsland to select, say, two or three badly-affected tea plants, and examine each separately. I would wish him to get a small bottle, to be used for each tea bush. He should proceed by carefully breaking down the earth from the branches and stems, and having 100 or so of all the insects seen in these collected and put in the bottle. He will pick the insects up without injuring them by means of a twig dipped in the spirits of wine, and applied to the insects. He should then carefully remove the earth and cut a trench across the face of the ground in which the bush stands for a depth of, say, 3 feet. The trench should form a perpendicular face so as to reveal all the subterranean workings of the ant. The vertical face should then be advanced on to the bush, by cutting away a slice of 2 inches at a time. If combs are found, these should be carefully removed (or large pieces of them) and laid out on the ground to harden in the sun. Samples of the combs are necessary for a complete examination of the species. As the section is advanced, a series of all the insects found should be picked up, more especially the queens, soldiers, and others that seem different in shape, size, or colour found above ground and within the branches and stems of the tea plant as also below ground and within the combs. I have suggested that two or three affected plants should be examined so as to make sure that all the peculiarities are examined, recorded, and specimens collected. When this has been done, I shall be greatly obliged if Mr. Winsland will give me a description of his observations and furnish me with the samples of insects, combs, or mud formations characteristic of the Colony.

WHITE-ANTS. Small White-ants. *Conf. with page 342.* **Combs Necessary.**

2. I have gone into these details, since it would seem to me, from recent enquiries in Assam, that we have not only the two forms popularly described in my paper (copies of which have been supplied to you), but possibly two or three more forms. Any suggestions aimed at the eradication of the pest must of necessity follow, not precede, the determination of the species. So far as my observations go, the "raiding ant" occurs mainly on high land and light soil, in fact, mostly old grass land. In such situations it is not uncommon to find large, oblong hard black structures, as large as the human head, lying half imbedded in the ground. These can be kicked about without being injured, but on being cut open are found to be ant-hives. They are full of a small insect, not unlike the "raiding ant" found on the tea bush. In one garden I picked up the other day a dozen of these hives in half an hour's time, scattered all over a plot of young tea badly affected by the destructive ant. So far, I was not able to establish conclusively that these were the breeding homes of the "raiders," but I think that highly probable. If confirmed, it should be the duty of the planter to have all the hives carefully collected and burned. Now, Mr. Winsland would advance

"Raider" White-ant. Superficial Hives. *Conf. with page 342.*

Pseudoneuroptera (Termitidæ).

TERMES TAPROBANES.

our knowledge of this subject materially if he would be so good as to look for the surface ant-hives or combs that I have described. If not found by him, that would go some way toward showing that they were unconnected with the "raiders." If they are found by him, then I should like if he would try and see if he could trace underground passages leading from the surface hives to the tea bushes being destroyed. I was unable to discover a queen ant within any of the superficial hives examined by me. This circumstance I am unable to account for, unless the queen be buried in the ground, and thus apart from the superficial breeding hives. If Mr. Winsland finds below the tea bush a hive with combs and queen ant, he would prove that the surface hives were unconnected with the "raiders." So far as my imperfect opportunities have allowed me to prosecute the enquiry, it would seem probable that the "raider ant" has no underground hive, combs or queen. It appears to live almost on the surface of the ground and within the stumps of the more or less destroyed stems and branches. I have thus asked Mr. Winsland to carefully dig out, as it were, two or three invaded bushes by a trench, as described, in order to settle this point.

Conf. **with Account of Ceylon Depredator,** *page 343.*

White-ants Kill Tea Bushes.

3. You will see that my knowledge of this subject is too imperfect to justify me giving any positive assurance of our being able to eradicate the pest. That white-ants do actually attack and kill tea bushes, more especially young tea or shoots from collar pruned tea, I have no manner of doubt. You are aware, however, that many planters of long experience refuse to allow this, and say that when the ant appears to be doing damage, it is only a natural consequence following on the death of the bush or shoot caused by the borer caterpillar. There need be no doubt on this point. The ants are dormant during the dry season, and commence depredations towards the middle and latter half of the rains. Before they have resumed operations, therefore, all healthy bushes in an affected area should be carefully watched. The borer drills a neat round hole into the lower portion of the stem or branch, and its presence may generally be discovered through the little dung heaps that are seen to collect on the ground near the entrance to his borings. In gardens badly affected by white-ants, as much as 20 or 30 per cent. of the bushes may be seen injured; and surely so high a percentage of borer-worms could easily be discovered, since each year they very possibly attack new plants or new branches. That is to say, each individual does not live much over 18 months if so long.

Borer Caterpillars. *Conf. with para 687.*

Cure for White-ants.

4. I believe the most rational cure for white-ants will be found to be—

(*a*) Thorough cleanliness; by which I mean, all mud deposits systematically removed, accompanied with deep and repeated hoeing.

(*b*) When the bushes have been severely injured, collar-prune.

(*c*) When collar-pruning has to be resorted to, it should be not less than 1 or 2 inches below the surface of the ground —never above.

White-ants.

(*d*) Heavy pruning, or collar pruning, should be at once followed by painting all the wood, and even the exposed portions of stems and large branches with my special preventative paint. You will find a description of that fluid in the paper alluded to above (*see pp. 363-66*). I have, as you are aware, called it the "Gondal Paint," in reference to the Native State in which I obtained the suggestion of the value of that preparation. All my subsequent enquiries have strengthened me in the opinion, that that paint is the most valuable preventative against white-ants as yet discovered. Tar has a strong tendency to kill the bark, a ring being formed where the tar was applied, that looks as if a rope had been tied tightly around. The tar would doubtless protect the wood from white-ants, but it cannot be said to have no injurious effects. The Gondal Paint is perfectly harmless.

WHITE-ANTS. **Tar Injurious.** **Gondal Paint Harmless.**

5. The objects of the above recommendations are based upon certain well-established facts. White-ants will not live long in localities where they are repeatedly disturbed. It is on this account that they are most destructive on young gardens and old nurseries: the natural operations of cultivation driving them from the ground. But if left alone for four or five years, they produce results that affect the whole after-life of the plant, so that they should not be regarded as a temporary plague. Exposed wood dries up, and is thus prepared for the depredations of the white-ant. By collar pruning below ground, and by the cut surface being immediately covered over with earth, the wood is not exposed to the withering and drying effects of the atmosphere. If you further completely coat all cut surfaces with the Gondal Paint, the white-ants will not look at them for at least a couple of years.

6. In conclusion, I would suggest the desirability of your laying this letter before the Tea Association, since its publication may ensure a larger number of workers and observers, than if it is treated as private.

OTHER PESTS.

CHAPTER XV.

OTHER ANIMAL PESTS.

711. Having dealt with the chief insect pests of the tea garden, there remain to be mentioned a few animal pests that do not belong to the CLASS INSECTA. It need hardly be remarked that wild elephants often do considerable damage both by trampling down the tea bushes and by pulling them out of the ground. Stray cattle also harm the bushes by breaking off the branches. Occasionally land rats are present to such an extent as to be positively hurtful. A letter in the Journal of Agri.-Horticultural Society of India (*Vol. V., Proc. 27th January 1876, p. x*) submitted by Messrs. W. Moran & Co. from one of their managers in Cachar, states that rats "are very destructive in gnawing off young tea plants, level to the ground and eating the roots." In the Duars hares are a cause of much anxiety especially with young plantations and on grass land. They eat the leaves, shoots, etc., and kill the plants.

Elephants. Cows. Rats. Hares.

712. Of Darjeeling District, it has been said that land crabs are sometimes injurious, more especially in perforating drainage embankments. But passing over all the higher forms of animal life that may occasionally or indirectly injure the tea, there may be said to be three Classes of animal pests, in addition to those that fall within the Insecta. These are the MOLUSCA or Snails and Slugs: the MYRIAPODA or Julus-worms or Millepedes: and the ARACHNOIDEA or Spiders, Mites and Scorpions.

Crabs.

MOLUSCA.

LXVII.—The Snails and Slugs.

Snails and Slugs.

713. Two or possibly three species of Slug (LIMACIDÆ) are common on tea, and do considerable injury to the leaves. I was not able to devote much time to the study of these, but made some collections. (*Tube No. 51.*)

714. Of the snails, one species I found fairly plentiful, especially in seed gardens. Samples of this were sent to Colonel H. Beddome for determination and he has been good enough to inform me that it is Helicarion salius, *Benson.* (*Tube No. 82.*)

The treatment usually pursued in Europe, when slugs or snails assume the proportions of pests, is to scatter lime over the crop. The first dressing may not kill the slugs owing to their slimy exudation throwing off any substances that may adhere to them. After one or two applications, the lime finally takes effect and the slugs are killed. It is in the seed garden or on tea under shade, where slugs and snails are most prevalent. They have been mentioned here mainly as denoting a possible danger from too much moisture in the soil or injurious shade. **SNAILS and SLUGS.**

MYRIAPODA.

LXVIII.—The Julus-worms or Millepedes. **MILLEPEDES.**

715. It would be difficult to find a neglected and untidy tea bush in Assam that did not contain a few large dark-red Millepede worms, perhaps from one and a half to 3 inches long. On being touched these roll themselves up and fall from the bush to the ground. They are well known to the planter and his labourers, but are universally regarded as harmless. European writers usually speak of the Julus-worms as living upon decaying vegetable matter, but occasionally as attacking living plants as well, and thus becoming pests. Many species are also believed to eat worms, slugs and caterpillars. How far the species found in the tea garden may be friendly is a point that deserves to be investigated. **Some are Friendly.**

MITES.

CHAPTER XVI.

ARACHNOIDEA.

LXIX.—The Spiders, Mites, Scorpions, etc.

716. One of the chief peculiarities of the members of this Class may be said to be that the head and thorax are completely fused into one portion of the body. In the Spiders (proper) this is separated from the abdomen by a constricted portion very similar to the jointed process in wasps. The spiders may be at once recognized as distinct from insects by the fact that they have four, instead of three, pairs of legs. In the Mites (the ACARINÆ) there is no separation of thorax from abdomen. In some of the mites such, for example, as the so-called Red-spider, the larvæ have six legs, and the mature mites eight. But in a large and important series—the Gall-mites—there is usually only two pairs of legs.

Only One Mite Described in 1881 as Found in Cachar.

717. Until very recently the Mite that has come popularly to be designated "Red-spider," was the only member of this class supposed to exist on tea. The late Mr. Wood-Mason devoted nine months in Cachar (during 1881) to the study of the Mosquito and Red-spider, but in his report of his investigations he makes no mention of his having come across any other species of the ACARINÆ. Mr. Wood-Mason was Entomologist to the Indian Museum, and the circumstance indicated may perhaps be admitted as suggesting the probability that, at the time named, no other Mite had appeared as a tea pest. Of course his silence as to all other insect pests might be taken as indicative of their comparative unimportance. But, as the Red-spider was a new species which Mr. Wood-Mason very elaborately figured and described, one would have expected a special allusion to other allied Mites, had he come across such during his study of Red-spider. Mr. E. E. Green published in 1890, in his *Insect Pests of the Tea Plant*, descriptions of two other species of Mite (in addition to Red-spider) as met with in Ceylon. During my explorations in Assam in 1895 I came across the three forms mentioned by Mr. Green, as well as one or two additional species. It would thus appear safe to infer, that the past 15 years or so, has witnessed a great increase in the number of species of Tea Mites as it has seen a wider distribution of the losses attributable to this series of pests.

Great Increase in Number of Species Found on Tea.

RED-SPIDER.

Conf. with paras. 25, 46 (4), 53.

92. (a) Tetranychus bioculatus, *Wood-Mason.*

THE TEA RED-MITE OR RED-SPIDER.

References.—*Wood-Mason, The Tea-Mite of Assam, 1884, Journ. Agri.-Horti. Soc. Ind., Vol. I., n. s. Proc., 9th Sept. 1868, p. lxix (Letter by S. E. Peal forwarding specimens and drawings of "Red-Spider") Samples were examined by Dr. Stoliczka who said it was a species of Acarina and possibly a species of Thyroglypus, Peal, Vol. IV., p. 126; Tukvar Tea Company, Vol. VI., Proc., 19th Sept. 1878, p. xxxix; Vol. VI., p. 85; Treatment of Red-Spider in Cachar in 1878; H. C. Sproull in Vol. VII., Proc., 27th Sept. 1882, p. xxiv; Proc., 30th Dec. 1885, p. cxciv; Indian Tea Association Report, 1892, p. 31; Schrottky's Articles on Agriculture (Tea Planting), 1878, pp. 31-35; Tea Cyclopædia, pp. 38-39, 40, 56-66; Notes on Tea in Darjeeling, pp. 45-49; Tea Planter's Vade Mecum, pp. 100-101; Green, Insect Pests of the Tea Plant, 30-35; Baildon, Tea in Assam, p. 46; Bamber, Chemistry & Agri. of Tea, pp. 253-254; Vœlcker, Report on Improvement of Indian Agriculture, p. 267; Indian Museum Notes, Vol. I., 169; II., 173; III., 26, 46-50; IV., 42; Cotes, Insects and Mites, etc., 49-56; Mites, Journ. Micro. Soc., Calcutta, Vol. IV., (1895), pp. 36-41; Christison, Darjeeling News, April 11th, 1893, also correspondence to date.*

(*Reg. No. 4; tube No. 180.*)

First Made Known in 1868, and in Assam.

718. HISTORY.—From the facts briefly indicated by the above citation of reports and correspondence, on the subject of this pest, it would appear that it was first made known in Assam, shortly after the discovery of mosquito (1868). To **Mr. Peal** belongs the honour of having been the first to furnish specimens and drawings of it; and these were submitted to the late **Dr. Stoliczka** for opinion. **Mr. Peal** in his letter accompanying the samples, gave it the name of red-spider. It would further seem to have appeared very shortly after in Cachar, and much later (1876) in Darjeeling. The opinion is very generally held that it was conveyed to Darjeeling along with some Assam indigenous seed. **Mr. Peal** in a paper that will be found in the *Tea Cyclopædia,* says that he had found it on the (*roghu kadam*) tree (**Anthocephalus Cadamba**), but whether it had gone from that tree originally to the tea, or from the tea to the *roghu,* he had been unable to establish. In a further passage **Mr. Peal** alludes to the fact that the disease may sometimes be found on one or two bushes, in the middle of an expanse of tea not affected, and from that circumstance he assumed that it was possibly carried by insects. **Mr. Wood-Mason,** in his scientific monograph, fully disposes of that idea. It does not belong to the group of mites that are carried by insects.

Recognised by Peal as Form of Red-spider.

Appear in Darjeeling, 1876.

Conf. with p. 390.

Is not Carried by Insects.

(Arachnoidea Acarinæ).

TETRANYCHUS BIOCULATUS

Mr. Wood-Mason's paper on this pest appeared in 1884, and it put at rest once and for all the identification of the species. It was extremely valuable in that respect, but unfortunately Mr. Wood-Mason did not attempt to study the number of generations a year, nor the condition and place of hibernation, nor did he propose any remedial measures. From the planter's point of view, therefore, his researches were singularly devoid of practical results. And what is more surprising still, during the 15 years or so that have since elapsed, we have made no progress. Every writer on the subject has contented himself with republishing extensive passages from Mr. Wood-Mason's Entomological paper, or with furnishing speculations as to the origin and treatment of the pest.

No Progress During Past 15 Years.

Hibernating Condition not Known.

719. We do not know if it hibernates in the form of an egg or in a pupal stage: we are ignorant as to where the hibernating germs are located during the inactive period: we do not know how many days the individual lives, nor the number of generations that take place a year. Is it, therefore, to be wondered at that no progress has been made in its eradication? We are still in the stage of discussing individual opinion, unsupported, for the most part, by ascertained peculiarities in the life history of the mite, and are as near the solution of the problem of extermination of this very abundant pest as we are with mosquito, green-fly, scale-bug, etc., etc. The ignorance that prevails as to the life histories of pests that are effecting losses that may possibly in the aggregate be something like a million sterling a year, is, to say the least, very surprising. It is no doubt necessary to get the correct scientific names of pests, since thereby experience in other parts of the world is rendered available, and the study of the life problems very possibly greatly simplified, but when we do know that our red-spider *is* **Tetranychus bioculatus,** *and that it is a closely* allied form to the European species, **T. telarius,** we have been told all that, as a rule, the Entomologist can tell us. The further study, leading up to the discovery of when and where the pest can be most easily assailed, has to be accomplished by the practical planter, who alone has the opportunity necessary to test one theory after another.

Location of Hibernation not Known.

Number of Generations a Year not Known.

Personal Opinions Unsupported by Ascertained Peculiarities in Life History.

Scientific Names of Pests.

Duty that Devolves on the Planter.

Hibernation of the European Species.

720. Speaking of the European species M. Dugès found in a garden near Paris that the red-spider hibernates under stones and in shady corners within the walls: further that it rests in what might be designated a pupal state, not as an egg. According to some

writers, the red-spider never leaves the tea entirely. It becomes inactive and scarce during certain months, and active and abundant during others, but can always be found especially under shade. On the other hand, it has been repeatedly recorded that in India the pest originates most frequently near the coolie lines or along roadsides, or near old open main drains that are not cleaned out. Fresh manure brought from the lines has been sometimes spoken of as having originated an outbreak of red-spider. Assuming that the Indian species hibernates, in a manner somewhat similar to the European form, the observation of its starting near the lines might be supposed as pointing to a direction of eradication. But experience in methods of pruning and destruction of prunings, would seem to suggest that hibernation may take place on the plant itself.

RED-SPIDER.

Probable Hibernation On Walls, Faces of Drains, etc.

Conf. with para. 146.

Fresh Manure Observed to Originate the Pest.

Experience of Pruning Would Seem Indicative of Hibernation on the Bush.

I have alluded to these opposing theories as denoting the urgency of more thorough enquiry than has as yet taken place.

721. Description.—After the very exhaustive account of the mite published by Mr. Wood-Mason, and republished by Mr. Cotes and others, it is hardly necessary that I should devote much space to the discussion of even the leading characteristics of this remarkable pest. To the naked eye it appears like a red speck, but under the microscope it is seen to have certain parts of different shades, the prevailing tint being scarlet. The eggs are laid in little sheltered spots on the upper surface of the leaf, such as near the midrib or alongside of the veins. They are small spherical bodies of various shades of colour until ultimately they become red as the young are about to be hatched.

Eggs.

722. The young red-spiders are at first six-footed, and Mr. Wood-Mason tells us they " do not attach themselves as parasites to the bodies of insects and spiders, as do their distant relations the Trombidiidæ, nor undergo any of those strange changes which many other mites pass through, in the course of their development, but attain to the adult condition by a simple change of skin that usually, though not perhaps invariably, is made on the same leaf as that on which they emerged as larvæ from the egg. The shells of the hatched eggs remain glued to the leaf for some time as microscopically small objects resembling porcelain saucers. "

Do not Attach themselves to Insects.

Simple Transformation.

723. The skins thrown off by the larvæ also remain attached to the leaf as white specks dispersed over the surface of the invaded leaf.

Cast off Skins.

Arachnoidea (Acarinæ).

TETRANYCHUS BIOCULATUS.

Web Spun Over the Leaf.

724. The males are considerably smaller than the females, and pointed at the anal extremity. They live together in colonies, the vast majority of each colony being females. The upper surface of the leaf is enveloped in a fine web that is rendered visible in the early morning, through the coating of dew upon it. This, as Mr. Wood-Mason originally suggested, is formed as a protection against slight showers of rain. When destroyed by heavy rain the mites are doubtless swept away and killed, but the pest reappears again with the first bright warm day, owing to the eggs not being destroyed by rain, however severe. Time after time the mites may be killed by rain and still the pest return, and this will continue until all the eggs that exist have been hatched. But should the intervals between the showers not suffice to allow of a new supply of eggs being laid, the pest will in time be entirely destroyed. It is on this account that, with the establishment of the monsoons, the pest, as a rule, gradually disappears, but with insufficient rain or long intervals of dry weather the pest may be enabled to exist practically throughout the year.

Continuous Rain in Time Kills the Pest.

Injures the Leaves by Withdrawing the Sap.

725. Depredations.—The mite injures the tea by withdrawing the sap, by means of its " pharyngeal pump with which it, like all other arachnids, is provided." At first the leaves look mottled light and dark green, but in time the punctured portions turn brown and the leaves assume a bronzed, dry, crumpled appearance and, when badly injured, fall off the bushes.

Appears Firs on Lower Mature Leaves.

726. Red-spider is essentially a pest of the Spring, in other words, of the dry hot months. It appears, first of all, on the old mature leaves on the lower and outer circumference of the bush. In time it gradually ascends and invades the whole bush, and thus checks completely the flushing. As already remarked, it very often commences near the coolie lines, and spreads along the roadsides, or accompanies the direction of the main open and dry drains, and in such a manner as to suggest that it may possibly be distributed from its point of seasonal origin by the clothes of the coolies. Mr. Wood-Mason says, "The tea mite, so far as I have been able to make out, usually first effects small patches consisting of a few bushes, whence it rapidly extends over the whole or a large part of a garden. It always seemed to consist of numerically larger and more active societies on the bushes of very old gardens, from which it never appeared to be entirely absent, as vigorous societies were to be obtained therefrom

Usually Appears near Coolie Lines on Buildings.

Most Prevalent in Old Gardens.

as often as I wanted fresh material for my observations."* Mr. Bamber remarks that, though the bushes near the coolie lines are almost certain to be first attacked, these bushes are rarely seen to suffer much from the effects of the blight, as the soil is always in good condition, and they are accordingly able to throw off the effects of the attack. "Where the soil is in poorer condition, the bushes are far more affected, the older leaves assuming a dry hard appearance and character, by which absorption of atmospheric food is largely prevented, and the bushes cease to flush." Mr. Green remarks—"An attack of red-spider does not immediately affect the existing flush. The insect feeds only upon the older leaves. But from the continued visitation, and the loss of sap imbibed by the insects, the leaves become dry and curled ; cease to perform their proper functions ; and in bad cases fall off, thus weakening the whole tree."

RED-SPIDER.

Unhealthy Bushes Most Affected.

Badly Injured Leaves Fall off.

"The pest is most injurious during the dry weather. Although light showers do not interfere with its habits, it seems unable to withstand continued and heavy rain, and at such times can only exist in sheltered spots. Trees growing under overhanging rocks afford strongholds for the pest during the rainy season."

Most Injurious in Dry Weather.

727. ***Influence of Pruning on the Pest.***—The most diverse opinions have been recorded as following heavy pruning. Thus, for example, Mr. Green writes: "A well-known planter of great experience tells me that he has repeatedly noticed that a bad attack of red-spider follows a few months after heavy pruning. In one case it was particularly noticeable, when a small patch in the middle of a field was pruned, while the rest was allowed to run up. A few months after this very patch looked quite purple against the rich green of the surrounding tea, the boundary being abruptly marked by the difference of tint." A planter whose opinions are published by Mr. Cotes (in *Insects and Mites, etc., p. 56*) says, "Red-spider does not attack heavy-pruned tea as a rule." *The Tea Cyclopædia* says, "It has been noticed that, in cases where plants were cut down almost to the ground, and the prunings burnt, and buried in the form of ash, the

Effect of Heavy Pruning.

Contradictory Views.

* That remark may be accepted as having reference to the term of Mr. Wood-Mason's residence in Cachar, *viz.*, from March to November 1881.—*G. W.*

TETRANYCHUS BIOCULATUS.

pest appeared on the new growth. Heavy or light pruning seems to make little difference."

Influence of Season of Pruning.

728. The season of the year at which prunings are accomplished would appear, however, to exercise a distinct influence. The following passages from letters by planters in the *Tea Cyclopædia* may be taken as expressive of the usually accepted views :—" I noticed the spider commenced on the garden first pruned, and seemed to attack each garden in the order it was pruned." Another planter says, " If planters would only delay their pruning for a few weeks longer, after the flush has stopped, they would find that the blight does not make its appearance so rapidly as usual." Here is another excellent example : " About the middle of December 1876, a section of the garden was pruned, and about the middle of February 1877 the adjoining field was pruned; the former was red with spider in 1877, while the latter was quite green. I attribute the attack of these spiders to early plucking as much as to early pruning. In 1878 both these patches were pruned about the end of January, and both were well covered with spider." The Cachar planter, whose views were published by Mr. Cotes, speaks of red-spider appearing first upon the early pruned tea. An Assam planter (*l. c., p. 56*) says, " In connection with red-spider, it may be of interest to you to note that this blight rarely, if ever, attacks bushes pruned after the last week in March. For three years I have kept small plots of bushes unpruned till the last week of March, and this year I have kept some 30 acres unpruned till after the third week of March, the difference of the plots so treated being now very marked ; that portion of same plot, early pruned, being more or less covered with blight, and the later pruned throwing out shoots without a sign of blight."

Late Pruning Advantageous.

Rarely Attacks Bush Pruned in March.

Late Pruning the Best Remedy.

" I am of opinion that late pruning—not before the first week in April preferably—will be found the best remedy or rather preventive for this blight ; the bushes liable to it will probably get the blight on them before they are pruned, but the pruning will remove a good deal, and the bush will throw out shoots straight away without a check."

729. I have had no personal experience on the point here raised, namely, the prevalence of red-spider on early pruned tea, and consequently of the value of late pruning as a preventative measure. I was told, however, that had been the experience of a very large number

of the planters whom it was my good fortune to meet in Assam. Without desiring to speak authoritatively, therefore, the suggestion of three possible explanations may be here submitted for consideration:— **RED-SPIDER.**

1st.—It is accepted as correct that the pest is mainly distributed by the clothes of the coolies. Late pruned tea (*i.e.*, pruned in March or April) would not begin to flush, until the period of chief distribution of the pest had been passed. Not being visited by the pluckers much before June, late pruned tea would stand a chance of escaping contamination, and if contaminated at the time of first plucking, the pest would soon thereafter be checked by the establishment of the monsoons. But this explanation of necessity almost presupposes that the pest does not hibernate on the bushes of plots that are annually invaded, and that it has to be brought to them. Finding in the plots annually invaded more favourable conditions than in the other portions of the estate, the pest annually develops there first and spreads to the other portions of the estate later. If the pest hibernates on the bushes, we would have to look for another explanation to account for its not at once starting on the unpruned tea in March and April. Pruning with the pest in activity, should only more thoroughly distribute the germs over the late pruned plot itself, and possibly also carry the pest over the remaining portions of the estate.

Late Pruned Tea Would Mean Late Plucking.

Does not Hibernate on the Bushes.

If the Pest Hibernates on the Tea Another Explanation Must be Found.

2nd.—Early pruning, by the shaking of the bushes, may distribute the mites to the parts from which they had begun to withdraw. By late pruning the hibernating mites may become fixed on the very parts that are removed.

Late Pruning May Remove Parts Bearing Hibernating Germs.

3rd.—The impetus to renewed activity on the part of the pest may be dependent on the ascent of the plant sap. This would presuppose that the insect hibernates on the plant. But if these two statements can be demonstrated as facts, then it would not be difficult to believe that pruning is a direct agent in originating or rather expediting the ascent of the sap, so that late pruning would mean a delay in the date of commencement of the ascending current. Were that so, it would be easy to account

May be Influenced by Ascent of Sap.

TETRANYCHUS BIOCULATUS.

Lateness of Ascending Sap in Assam Indigenous, Accounts for Comparative Freedom from Red-spider.

for the advantage observable, *namely*, the plant would be carried nearer the date of the bursting of the monsoons before being dangerously invaded. It may, on this line of reasoning, be stated that the later date of the ascending sap, in the higher *jat* Assam indigenous teas, accounts for their comparative immunity from this pest.

Fixed Annual Yield Little Affected by Season of Commencement of Plucking.

730. It seems probable that the last may be the most satisfactory explanation. Whatever theory be held, however, the fact remains that a very large number of planters affirm that late pruning is so beneficial as to almost amount to a remedial measure. It would, therefore, seem desirable that, with badly affected plots, this system should be pursued. The return obtained from plucking such plots before June must be very small indeed, and the risk of distribution of the pest very great. Indeed many of my planter friends have assured me that you can only take so much off a bush per annum, but that that quantity you can obtain whether you defer or precipitate the date of commencing plucking. There would seem no occasion to anticipate, in Assam at all events, any material loss through deferring the date of commencement of plucking of plots recurrently affected with red-spider, so that the beneficial effect of late pruning should be thoroughly tested. Even if there be a loss, it can only be the very small amount that is collected from pest-invaded bushes at a considerable risk to their health. If bushes are badly attacked by a parasite, it is, as a rule, wise to do nothing that will tend to force them to flush. By reserving their strength in that direction, you are husbanding future returns; by forcing on flushing you may be supplying the food for a protracted visitation. Viewed in that light, therefore, if it be a fact that, a delay in pruning lessens the severity of the scourge, every advantage should be taken of that discovery.

Forced Flushing Unwise.

In Assam Red-spider is Scarcely a Calamity.

731. REMEDY.—It may be here explained that in Assam red-spider can hardly be regarded as a serious calamity. Most planters look upon it as a necessary evil, that is in a measure compensated for by the high quality and good yield that, with liberal cultivation, may be obtained after the pest has passed off. Over and over again I drew the attention of managers to plots of their estates, almost red with this pest, and obtained the almost invariable reply, "Yes that's a bad bit." That any further consideration was desirable, or that it could be remunerative to purchase so many tons of sulphur or other insecticides, to

The Tea Red-mite.

check the ravages of the pest, would seem never to occur to them. In some half a dozen gardens at most did I find red-spider a cause of anxiety, and in the very worst garden of all, the superintendent laughed at the idea that white-ants could ever assume the condition of being half so serious as the annual visitation from which he suffered during the Spring months through red-spider. Not many miles distant, the manager of another estate was in anxiety as to white-ants, and could hardly be induced to look at red-spider. Such illustrations brought home to one, on moving day after day over the tea district of Assam, the diversities in soil, climate, position, race of stock, etc., etc., that must be supposed to favour or oppose the existence of certain pests. They also conclusively demonstrated the danger of allowing a pest to harbour in an estate, until it had assumed gigantic proportions, before remedial measures were deemed necessary.

RED-SPIDER.

Red-spider *versus* White-ants.

732. It seemed to me satisfactorily proved that the less importance of this pest in Assam, as compared with Darjeeling or even Cachar, must largely be accounted for by the greater abundance of the late flushing finer *jats* of Assam indigenous stock. In all the Assam gardens, where I found the pest to prevail badly, the stock (at least in the invaded portions) was low *jat* hybrid or China bushes. The pest invariably originates in such positions or in old and sickly plots and badly drained and imperfeetly ventilated gardens. Once fairly established, it doubtless rapidly attacks old and young bushes, even nurseries, and high and low *jats*, all alike. I did not, however, come across an instance where the pest had originated in a nursery, nor an example where it was traced to abandoned tea. The frequency with which it first appeared near the lines or factory, suggested to my mind the idea of hibernation in such situations. Of course the other explanation might be given that the bushes around the lines and factory are possibly the older parts of the garden, and, moreover, being more convenient, are likely to be first pruned and consequently earliest in leaf.

Checked by the Prevalence of Assam Indigenous Stock.

Originates on Inferior *Jats*.

Conf. with para. 53.

Effect of Early Pruning.

733. But it is not in Assam alone where one hears of red-spider being viewed as a pest of comparatively little consequence. The author of *Notes on Tea in Darjeeling* says, "This blight is not really half so bad as supposed, as, if the bushes are in a fair order, it only retards the flushings slightly. And it is only the sickly bushes that suffer so very badly. The remedy for red-spider is good cultivation and careful work, and it can soon be (to a great extent) got rid of. Hot

Retards Flushing.

Arachnoidea (Acarinæ).

TETRANY-CHUS BIOCULATUS.

scorching weather brings on the spider, and rain prevents its increase or, at any rate, retards it. All the remedies—lime, sulphur, etc., are more or less useless, let alone the expense."

Applicable to Assam.

734. I have for some time held very similar views regarding red-spider to those just quoted, but what little knowledge I possess on this and other aspects of the tea-planting industry, has been acquired during a rapid inspection of the Assam gardens, and my remarks should, therefore, be read as applying to Assam. Mr. Christison seems to have become aware of my being unfavourable to the insecticide treatment of tea pests, as a primary agency in the warfare against these enemies. Accordingly in a letter, which appeared in the *Colonial and Indian Mail* (which I have ventured to attribute to Mr. Christison), he says, "In regard to Red-spider I have had at least fifteen years' sad experience in battling against it. The soil of the gardens I managed seemed predisposed to this blight and favourable to its propagation, and I could not imagine any gardens to be worse with it than they were for years. From 1880 to 1885 this pest was in fact a dreadful scourge; but it has been practically overcome by sulphur. I learn that Dr. Watt has no belief in the cure of blight by any application in that way, but after having applied sulphur in quantities of 3 to 20 tons annually since 1880, the effectual cure of Red-spider, at a moderate cost per acre, is with me no longer a matter of opinion, but something that has in my own experience been successfully achieved. It has also to be taken into account that the sulphur not only proves a remedy for the Red-spider, but for many soils a valuable manure."

SULPHUR CURE.

Insecticide Treatment in Early Stages.

735. These remarks, I submit, do not represent my position. I am quite willing to advocate that insecticide treatment, or any other remedial measure, should be prosecuted with energy, in the early stages of each and every pest. The planter should know the pests that are dangerous, and stamp them out vigorously, when and where they are found. It is the neglect to deal with the half dozen bushes or so, in the early stages of such visitations, that leads to the state of affairs when insecticide treatment, in my opinion, becomes inexpedient. But the primary aim should be not cure, but the discovery of methods of prevention.

Prevention Better Than Cure.

736. Mr. Christison estimates that the sulphur treatment of red-spider need not come to more than R20 to 25 per acre, (see letter in

The Tea Red Mite.

the *Darjeeling News*). A Cachar planter (whose reports have been published in Mr. Cotes' *Insects and Mites, etc., pp. 54-55*) puts the cost at a much lower figure "leaving out of consideration," he says, "all differences between sulphured and non-sulphured areas, and taking them as of the same value,* the difference in favour of the sulphured would be 44lb leaf or 11lb tea per acre for the whole month. The cost of treatment amounted to R8-4 annas per acre, so that with tea at 6 annas per pound all expenses would be recovered in two months." So long as the expenditure for 50 or 100 acres out of an estate of, say, 800 to 1,000 acres, might be put as the maximum required to check the distribution of the pest all over the estate, then insecticide treatment would not only be practical, but urgently demanded. But if the same plots of tea had to be year after year so treated, the point would be rapidly reached in which sulphur would no longer serve the additional purpose of a useful manure, but would become positively hurtful. The treatment of red-spider and other mites with sulphur has been pursued in Europe and America for a very long time, and the adoption of the practice in tea planting is thus fully justified. Mr. Bamber explains the action of the insecticide in the following passage :—"Dusting the leaves, when moist with sulphur, has been tried in Darjeeling District on a large scale, and with apparent success, the sulphur being probably slowly converted into sulphurous acid by the action of the air, which is poisonous to plant and animal life. When washed off the leaves by the rain, it would slowly become converted into sulphuric acid in the soil, where it would be utilized by the plant to supply the sulphur required for certain of its constituents, as legumin, which forms one-fourth of the dry substance of the leaf." On the subject of the action of sulphur on red-spider, Mr. Green writes me that he has doubts as to its value. In certain experiments which he performed, the insects, though closely observed, were not found to be affected. Mr. Green then adds, "I believe strongly in soap mixtures, but I think the soap is the active principal in them all, causing death by suffocation."

RED-SPIDER. SULPHUR CURE.

Yield Increased.

Limitation of Insecticide Treatment.

Recurrence of Pest.

Probable Action of Sulphur.

Sulphur is Doubtfully a Specific.

Conf. with para. 23.

737. But from my standpoint, if a blight or pest recurs time after time on the same plot of tea or similar plots of tea, it is time to look

Recurrence of the Pest.

* This qualification is due to the fact urged by the Cachar planter in his report generally, that the portions of the estate invaded by the pest are usually the most inferior and least productive.—*G. W.*

TETRANYCHUS BIOCULATUS: SULPHUR CURE.

Prevention not Cure.

Predisposition.

further afield than to a palliative treatment, such as the acceptance of an annual expenditure for sulphur. There is something materially wrong either in the soil, in the drainage, in the ventilation, in the general health of the stock, or in the class of stock itself, on such plots of land, that imperatively dictates prevention as both more effectual and more economical than cure. We must seek for the cause of the predisposition to pests and deal with that. In this search after prevention the pest itself will be more effectually dealt with at its weakest stage, but we must discover that stage in its life history. In nine cases out of ten I believe that the bad *jat* bushes or old and unhealthy clumps in which red-spider and other pests are invariably seen to take their origin, would be most economically treated by being uprooted, the land thoroughly deep soil drained and replanted with better *jat* stock. In my opinion it is a dangerous state of mind to accept the doctrine of insecticides as the cure for all the ailments of the tea plant, or even as practicable with a visitation that has taken possession of, say, half a million bushes at one and the same time. We have to deal with very different conditions to those of agricultural crops and orchard cultivation of Europe and America, and what may be practicable with these becomes in many cases wholly inapplicable with tea.

Uprooting and Replanting.

Doctrine of Insecticides.

738. It is in these respects then that I qualify my acceptance of Mr. Christison's views on the treatment of red-spider with sulphur. As indicating a side issue, I would give here a further passage from the Cachar report, published in Mr. Cotes' *Insects and Mites, etc.* The writer says—"Now that I know more about sulphur and its effects, I am convinced I made a great mistake in not applying it immediately after pruning. I have several reasons for saying so amongst which are—(1) Red-spider must hibernate somewhere in the bush; it cannot come spontaneously. One invariably sees it start on the old leaves, and work gradually up to the new growth which is always the last attacked, and I should not be surprised to learn that it remained through the cold weather in the *bark*. Therefore an application of sulphur in January ought to be as successful as in March. (2) The sulphur would go very much further on newly pruned bushes, and would also search out the bark, which it cannot do after the leaves form a covering. Moreover, there would be no fear of heavy rain for at least two months, nor would there be the

Season of Application.

Presumed Position of Hibernation.

high winds of February and March which waste a good deal of sulphur. (3) Although Mr. Cotes is not convinced on the subject, I still hold to my opinion that sulphur has an influence on blight" —(mosquito).

RED-SPIDER: SULPHUR CURE.

Supposed Beneficial Action on Mosquito.

739. Now it will be seen that, in the action on red-spider and the supposition of a similar benefit on mosquito, the writer must be supposed to presume that both pests hibernate on the bushes. If they do not do so, all his other arguments are meaningless. But why should we be ignorant on so all-important a point? Surely there would be little difficulty in having an isolated bush, or a few bushes, infested with the spider, carefully enclosed in a very fine wire-gauge house, for eighteen months or so, and carefully cut off from all external influences by being fenced in or cut off by a deep trench. If the pest returned to these at the same time as on the bushes left outside, we should obtain a fairly strong corroboration of the views advanced. Then again a powerful lens should suffice to discover the red-spider sheltered on the bark if that be its mode of hibernation. It would only be necessary to sit down on the ground (say in December or January) in the middle of a plot of tea that had been badly infested the previous Spring, and bring one's eye, by means of a lens, into a close inspection of every little detail of the bark, in order (after one or two futile endeavours) to at last discover the lethargic creature or perhaps its eggs, reposing under some little shelter or below clods or stones on the ground, underneath the bushes. In this case the hibernating condition is not so small, but that it can be discovered, and in Europe it has been so detected. The red-spider of the gooseberry bushes has been found to hibernate in the crannies of rough bark and that of the vine under the shelter of stones. All that is necessary to prescribe when and where palliative treatment can be most effectually applied, is a knowledge of the life history of the pest. Without that knowledge, blindfold experiment and theory must prove both expensive and unsatisfactory. It is on this account that I have laid so much stress on the opinions advanced by many planters as to advantage obtained through late pruning. If we can demonstrate these opinions as well-founded, we get another indication of a more rational and more effective treatment than with insecticides.

Experiments to Prove Hibernation.

Discovery of Hibernating Condition.

Late Pruning.

740. But to conclude this brief review of the opinions that exist on the subject of red-spider and its eradication, I may here give Mr. Christison's method of sulphur treatment—"Our process of application,"

Darjeeling Method.

TETRANY-CHUS BIOCULATUS.

Bushes First Wetted. Sulphur Dusted on the Wet Leaves.

he says, "is simple and inexpensive. We put sulphur in gauze bags or cloth of open texture, and after wetting the bushes thoroughly over and under the leaves, and the branches and stem, the sulphur is dusted over the whole bush—by shaking the bag with its contents over it. With a dry spell of weather and no wind, the garden will remain yellow for weeks which is most desirable."

Lime.

741. In addition to sulphur, lime dusted or white-washed over the branches and the stems, shortly after pruning, has been strongly advocated by many Assam planters as quite as effectual a treatment and in its secondary action as a manure more valuable than sulphur.

Muddy Water.

Adhatoda.

Conf. with paras. 1, 20-1, 292, 573, 589, 704, 758 and 795.

Tomatoes.

742. Syringing with muddy water was tried in Cachar, and proved in one respect effectual, namely, that it killed the mature spiders, but was altogether useless against the eggs. An infusion of Adhatoda is instantly fatal to red-spider, and it has by no means been proved that this might not be as effectual, it certainly would be less expensive, than sulphur. Similarly a preparation made from the leaves, stems, etc., of the green tomato would be beneficial, but it would have to be repeated time after time till each and every brood had been destroyed. The objection to the sulphur treatment,* as recommended by Mr. Christison, is its needless expense. The bushes have to be thoroughly damped before the sulphur is applied. The act of damping might in itself suffice if Adhatoda or Tomato infusion were added to the water. In Europe a soap and kerosine emulsion is that most generally employed, and the reports reviewed by Miss Ormerod in her Report of observations for 1896 show that the emulsion is most successful.

Kerosine Emulsion.

Expediency.

743. It may perhaps now be understood that it is the expense and difficulty to deal with a million or more bushes simultaneously that is the chief drawback to insecticide treatment, when once a pest, such as red-spider, has taken a firm hold of an estate. But it has no right to be allowed to obtain that supremacy. The insecticide materials and appliances should be at hand and used promptly on first appearance. Accidental visitations would thereby be at once checked. But until we are in possession of the full facts of the life of each pest, as also of the physical, chemical and vital influences that check or foster their development, we are not in a position to deal with them satisfactorily.

Conf. with para. 90.

* I am led to understand that Chiswick soap is a preparation that contains a large amount of sulphur. If that be so, its application might save the necessity of first wetting the bushes (*Conf. with para. 736*).—*G. W.*

A Red-spider Found on Under Side of the Leaves.

93. (c) Tetranychus, *sp.*

A NEW RED-SPIDER.

(*Reg. No. 99.*)

744. At Bor Phukri on the 12th July, I discovered what I take to be an undescribed species of Red-spider, belonging very possibly to this genus. It was in many respects very similar to the common form only considerably smaller and of a more uniform scarlet colour with a soft woolly appearance. It was universally found feeding on the under surface of the leaf (instead of on the upper), and it spun a small web near the base of the leaf to which it ran for protection. The larvæ, which I presumed to belong to this form, were seen to be at first quite transparent, but gradually to obtain two circular red spots one on either side of the rounded and swollen body, otherwise they were quite colourless. They had six legs, while the adult form had, like the ordinary red-spider, eight.

Feeds on Under Surface of Leaf.

745. DEPREDATIONS.—This form lives on the finer *jat* plants and on the young leaves, the third to the fifth (from the bud) never upon the old lower leaves. Instead of being bronzed, the leaves turn at first pale-coloured, almost white, but in time the base and margin, corresponding approximately to the portion over which the web is spread, withers, changes colour, and finally turns dark brown. The flushing stops entirely, and a very unhealthy appearance of bush supervenes.

Invades the Finest Assam Indigenous.

I subsequently came across this pest on one or two other occasions as, for example, at Mijikajan and Seconee. Fortunately, on each occasion, only a few bushes were affected, but I can well believe this might prove a more destructive pest, were it to become at all prevalent, than even the ordinary red-spider.

Since the date of my personal explorations in Assam I have had sent me from a garden in Sibsagar leaves, brown at the base and with colonies of the immature transparent mites each with two circular red lateral spots, so that I am led now to think this mite may be gradually becoming established. (*Conf. with page 390 especially foot-note*).

Is Probably Becoming Established.

746. REMEDY.—I would recommend attention being given to this subject, and every effort made to stamp out this new tea pest. Syringe the bushes with an infusion of **Adhatoda** or a weak soap and kerosine emulsion. Hard plucking and the instant destruction of the pluckings might also prove beneficial.

Kerosine Emulsion.

94. (c) Typhlodromus carinatus, *Green.*

FIVE RIBBED TEA MITE. *Conf. with para. 49.*

THE FIVE-RIBBED TEA MITE: THE PURPLE AND WHITE MITE.

(*Reg. No. 84 ; botanical specimens No. 11992.*)

Arachnoidea (Acarinæ).

TYPHLODROMUS CARINATUS.

747. History and Description.—This mite was first discovered in Ceylon by Mr. Green, and met with it in the nursery as well as on the plants in the tea estate generally. It was found by me all over Assam, but only on the indigenous or better class hybrids. I never came across it on the China plant.

Found on Assam Indigenous.

For the present I have accepted the insect found by me as identical with that of Ceylon, though, on comparing some samples kindly furnished by Mr. Green, the Indian form would seem to differ very slightly in the shape of the head and the lesser prominence of the marginal waxy folds. In the Ceylon form the adult mite is of a dull-purple colour with five white ridges, of a waxy material, running along the back, and a small ridge surrounding an hour-glass-shaped space at the front of the body (*Green*). In the Indian form the mite is almost quite elliptic in outline, is of a bright purple colour, and has three very prominent dorsal waxy ridges with two lateral additional ones inconspicuous, also the front portion of the body, which, for convenience, may be designated the head, is cut off by a straight transverse line and does not appear to form the hour-glass-shaped portion described by Mr. Green. In other respects the two forms, when compared side by side, seem identical both as to size, larval condition, method of throwing off the skin, and system of depredations on the tea.

Differences.

Dorsal Waxy Ridges.

748. In Assam I found this mite fairly prevalent, especially in association with the form described below, and which I have designated the pink-mite, but nowhere to such an extent as to specially attract attention. Since my return from Assam, Messrs. McLeod & Co. have, however, forwarded to me one set of samples, and Messrs. Duncan Brothers & Co. another, both from the Duars. From the correspondence that has ensued, I am led to understand that this mite has in that locality assumed the condition of a serious pest. But let me add I have only seen the bronzed leaves with the cast-off skins, not the perfect mite, so that I am by no means satisfied that the Assam and Duars forms are identical. Indeed there are certain peculiarities that would point to their being distinct, though undoubtedly closely allied. From the practical point of view as tea pests, they may be regarded as one and the same.

Assam and the Duars.

Doubtfully Identical.

749. Depredations.—Mr. Green tells us that, "It produces much the same result as red-spider: the leaves of the attacked plant

The Purple and White Mite.

become dry and bronzed as if sun-burnt, but they retain their shape, and do not curl up like those affected by the red-spider. If closely examined, the leaves are seen to be thickly dusted with very minute white specks, the cast-off skins of the insects, but the mite itself is so microscopic and dull-coloured that it is quite invisible to the unassisted eye. Unlike the "red-mite"* the "ribbed-mite feeds both on the upper and under surfaces of the leaf. The colonies seem to spread themselves evenly along the margins, leaving the centre of the leaf comparatively free." "It has its periods of increase and decrease, but these do not necessarily correspond with the fluctuations of the other species."

FIVE-RIBBED MITE. **Sun-burnt Leaves.** **Feeds on Both Sides of the Leaf.**

750. The following passages taken from the letters which accompanied the Duar samples may be here quoted: "This blight is only on the bushes of the Singlo Hill plants and looks very much like bad red-spider, only that there is not a specimen of that insect to be found in the garden." (*Letter, 7th May.*) In a further communication the same writer says, "I am afraid this blight is here getting serious. It is covering now something like 250 acres, of 1893 planting. All the Singlo Hill and Jaipur plants are affected with it badly. Amongst the Manipur plants I have so far noticed only a few bushes. It started in the Assam indigenous plants, and these are looking browner every day. The rain we have had, I thought, would kill it; but it seems, on the contrary, to be getting worse." (*Letter, 21st May 1897.*) On the 8th July the same writer reported that the blight "seems to be getting less in the older portion of the garden, but it is getting worse on the younger plant." On the 15th he again wrote that all the affected leaves were falling off the bushes, but that, as the old ones fall off, the pest ascends to the new leaves. On the 1st September 1897, he finally reported "nothing more of the blight is to be seen now except on opening out the bushes, one can see the bare stem without any branches as far as the blight affected them and some fallen-off blighted leaves, hanging in the forks of the branches. The bushes look as healthy and fine as they ever did."

Period of Activity in the Duars. **Leaves Fall off the Bushes.**

751. Another contributor wrote from the Duars on the 24th July: "I am sending you down by post samples of leaves that are affected with blight from which the bushes suffered so much during last

Suffered Most in June.

* The Red-spider of this report.—*G. W.*

Arachnoidea (Acarinæ).

TYPHLODROMUS CARINATUS.

month. I would be glad if you have these examined, and let me know what kind of blight it is. On examining the leaf through a glass I find it covered over with a very minute insect, very like white bug. The leaves affected with this blight turn brown and eventually fall off. I am also sending you leaves with parts quite dead, the leaf appears otherwise quite healthy. This blight only seems to attack young seedlings, very few of the larger bushes having any signs of it."

Two Pests in Association.

Subsequently in acknowledgment of my report on the samples, the following reply, dated 16th August, came to hand through the agents:—" I am inclined to think there are two distinct blights.* The one in which parts of the leaf become dead or rotten, while the remainder, to all appearance, is healthy, but in a great many cases have a mottled appearance. This may be the blister blight that Dr. Watt refers to. The whole bush eventually assumes a yellow and sickly look; in the other case, the leaves commence by getting brown all along the edge. This works inward till the whole leaf has assumed a brown colour, with white scales all along the sides of the midrib and veins. The leaves so affected eventually drop off, leaving the bare stems. It greatly retards the growth. The two-year old bushes have to a large extent, been attacked with it more or less since November last, but it became very bad during the month of June, after which it was less, but is still hanging about. I notice all the young gardens and extensions in older ones, around this district, have been attacked. I am inclined to think this blight has been imported in the soil in which the seed is packed and sent down from Assam. I have never seen it in this district before."

Cast-off Skins Mostly on Upper Surface of Leaf.

Attacks Young Tea.

Presumed to have been Imported from Assam, *Conf. with History, Red-spider, para. 718.*

752. The suggestion that this new pest may have been introduced to the Duars from Assam, by the soil used to pack seed, may be quite unfounded, but it is worthy of investigation. As possibly opposed to that idea, I would repeat, however, that there are certain features of the Duars mite that would point to its being a distinct species from that met with by me in Assam.

753. The purple-mite, as I called it, before I had the good fortune to receive from the author, a copy of Mr. Green's *Insect Pests of the Tea Plant*, exists throughout Assam, as may be seen from the extracts

* It may be here explained that it nearly always happens that two mites live in association. It seems thus probable that the preceding species (*No. 93*) may have been found along with the present (*Conf. with para. 781*).—*G. W.*

given below from my diary, in connection with the pink-mite. In only one or two localities did I meet with it by itself; it was generally found in association with the pink-mite, and much less abundant than that form, so much so as to lead me at first to suspect it might be the male, and the pink form the female, of the species. At Makum, however, I found the purple-mite under circumstances very similar to those described in the Duars, though the empty cast-off skins were distributed all over the under side of the leaf instead of being arranged on the upper surface and alongside of the midrib and veins —the condition in the Duars form. This is one of the most significant peculiarities of the Duars pest, and one that leads me to suspect that it may in reality prove a distinct species from either the Assam or the Ceylon form.

PURPLE-WHITE MITE.

Cast-off Skins on the Under Side of the Leaf.

754. Another peculiarity that may be here recorded. Certain leaves seem to be specially set apart for the purpose of breeding. On the under surfaces of these leaves will be found numerous thickened patches like little warts. On looking through the leaf these are seen as translucent, pale-coloured spots. It seems likely that, during seasons of drought, when the leaves get the condition often described by planters as "sun-blistered," that this pest is prevalent, the "blisters" being the structures here described. On careful examination they will be found to be cavernous formations within the tissue, just below the epidermis, and contain what I take to be the eggs of the purple-mite. Apparently the mites on escaping from these blister or wart-like houses wander off to other leaves to feed, and it would seem that on molting they congregate under the shelter of the veins on the upper surface. As a consequence the upper surfaces of the leaves, even to the naked eye, appear as if dusted along the line of the veins with very minute particles of pure white powder. These are the cast-off skins, which, in badly affected leaves, may be seen in thousands upon thousands. But I never came across, though I looked carefully over many samples, a warted or blistered leaf bearing also the powdery deposit of cast-off skins. In the supply sent me from the Duars, there might be perhaps one in ten of the leaves warted and devoid of the powdery deposit.

Blisters on the Leaves Possibly Breeding Houses.

Sun-blistered Leaves.

Cast-off Skins Lik White Powder.

Deposited o1 Upper Surface.

755. Still another circumstance of some moment may be here recorded. I never met with a leaf in the Duars supply with the

Arachnoidea (Acarinæ).

TYPHLODROMUS CARINATUS.

cast-off skins on the under surface of the leaf. In several instances, however, I found here and there the dead mites among the cast-off skins, and in consequence feel satisfied that I am correct in referring this pest to the purple or five-ribbed mite, but, as already stated, I have not examined the live mite of the Duars. In the few instances in which in Assam I came across the purple-mite, without finding the pink-mite as well, it was chiefly dispersed over the under surfaces of the leaves, and the empty cases were, as in Mr. Green's Ceylon samples, scattered over the surface instead of arranged under the shelter of the veins.

Attacks Young Bush Assam *Jat.*

756. But the history of the Duars pest agrees, in other respects, with the state of affairs that I found in Assam. It attacks the higher *jat* Assam indigenous teas, and is for the most part confined to young bushes. In fact I do not recollect finding it on plants much older than 5 or 6 years. The leaves turn at first pale-coloured, get dried up, and begin to bronze on the margin, the discolouration extending gradually over the whole leaf until, when quite brown, it falls from the bush. The pest thus advances from the old to the young leaves, and by the time of the monsoons being established the plants are next to leafless.

Kerosine or Phenyle.

757. Remedy.—All mites succumb very rapidly to a treatment with kerosine or phenyle. Mr. Green recommends, "one part of kerosine emulsion to eighty parts of water, or one of phenyle to two hundred and forty parts of water." "The nurseries should be watered with the mixture in the evening and with pure water in the following morning, unless rain should have fallen during the night. This treatment would not altogether exterminate the insects, as some of them are sheltered beneath the leaves, but I think it would prove to be a wholesome check to the many insect pests in the nursery. But after being pulled for planting, the plants might be dipped in buckets of the mixture, which would certainly free them and give them a fair start in the field. The stem and leaves only should be dipped, not the roots."

Seedlings.

Adhatoda.

758. A dangerous visitation, such as I have mentioned in connection with the Duars, should at the commencement of the outbreak be treated with kerosine emulsion and water or an infusion of **Adhatoda.** Every bush should be thoroughly syringed, two or three times at intervals of, say, one week. At the pruning season all withered leaves should be carefully cleared off the bushes, and

the whole plant thoroughly painted over with the emulsion and water. In this way it seems likely the return of the pest during the ensuing spring would be averted. THE YELLOW-MITE.

95. (c) Acarus, *sp.*

THE YELLOW-MITE; "THE APPLE-FOLIAGE BLIGHT": "SULKY." SULKY. *Conf. with para. 40.*

(Reg. No. 133; botanical specimen Nos. 10497, 11331, 11929, 11946, 11955 and 11991.)

759. HISTORY.—Mr. Green has been good enough to furnish me with a sample of leaves infested with the yellow-mite, which he provisionally named **Acarus translucens,** in his little work—*The Insect Pests of the Tea Plant.* He has also drawn my attention to the fact that the name **translucens** cannot, however, be given to the yellow-mite of tea, since Nietner had assigned it to a coffee pest that turns out to be a distinct species.

760. I have examined Mr. Green's specimens, compared them with the condition met with in Assam, and while fully satisfied that the Indian manifestation must be caused by some very closely allied mite, think it safer for the present to regard the two as distinct. In fact on the bushes, affected in the manner which I shall presently describe, I could not find the mite, but it seems probable that my failure to do so proceeded from the fact of my being in the tea districts during the season of their inactivity, and that accordingly I was but viewing the deformed leaves and buds of last year's operations. Indeed, until favoured by Mr. Green's samples, it was my intention to have described the visitation without venturing to definitely suggest a cause. At the same time I may remark that, the peculiar felted formation on the leaves had suggested from the very first a felt-mite, similar to those that for some time had been regarded as fungi and described under the generic name of ERINEUM. The careful examination of Mr. Green's samples, however, with the mite on them, and a comparison with the diseased condition found by me, leaves no longer any room for doubt as to the Assam plants being destroyed by a very closely allied mite to that met with in Ceylon. Season of Inactivity. Felted Condition.

761. On the 7th April, while on a visit to Khumtai (one of the Assam Company's gardens, then badly infested with "Blister Blight"), I discovered a bush here and another there in dark green foliage, through not having started to grow since the date of being pruned, Khumtai.

Arachnoidea (Acarinæ).

ACARUS, SP.

while the others around were covered with their Spring shoots. I also noticed that the leaves were crumpled on the upper, while, on the under surface, near the midrib and for some distance on either side, they were coated with a brownish-red tomentum that gave them the soft woolly appearance of the Spring foliage of the apple tree. On this somewhat fanciful resemblance, (and as a matter of convenience,) the name apple-foliage blight was suggested, for this very remarkable disease. I now observe that in Ceylon where a similar condition of bush prevails, the planters call the blight "Sulky"—a term fully expressive of the attitude assumed.

Sulky.

Found Everywhere.

762. Having once had my attention directed to this very remarkable disease, I practically found it in every garden throughout the Province. In some there might be as much as 5 per cent. affected, in others perhaps not more than one half per cent. Still the disease occurred everywhere, no garden could be said to be absolutely exempt from it. It is, however, most prevalent in Sibsagar District, comparatively rare in Dibrugarh and Nowgong: while, on the North Bank gardens, a slightly different form (*No. 11946*) occurs, so that I presume there may be several species of mite that all produce very similar distorted and diseased conditions of the bush. When it is added that bushes affected in this way make no attempt to flush until July at earliest, or perhaps not till August or September, some conception of the total loss to the province can be obtained. And even when they do flush, the amount of leaf secured is hardly worth plucking. So far as I was able to discover, bushes once affected with this blight never recover, but get worse and worse until finally they are killed. Indeed I believe this pest is one of the chief causes of the vacancies that are to be found all over most gardens. One very striking peculiarity, which I had noted while in Assam, and which I see is true also of the Ceylon pest, is the fact that the disease does not originate from a common centre. A bush here and another there may be affected without apparently having anything in common. It is certainly more prevalent in old, than in new, gardens, and on unhealthy, rather than healthy, bushes; but I have found it on seedlings in the nursery, on China bushes, on hybrid bushes, and on the finest Assam indigenous. All alike are liable to this visitation without there being afforded the slightest indication of any means of communication from the one to the other. Indeed, I may safely say

Total Loss to the Province.

Bushes Never Recover.

Chief Cause of Vacancies.

Affected Bushes Isolated.

All *Jats* Liable.

this disease puzzled me more than any other in Assam, and curiously enough I came across no planter who had allowed himself to recognise the plants so affected as being diseased. On my drawing attention to them, I got the almost invariable reply that they were sulky bushes and, from year's end to year's end, had done nothing. That opinion I have, as already stated, had reason to believe to be quite correct; once infested the bushes never throw off the blight, but each year get worse and worse. They have been heavy pruned by some planters, but, unless collar pruned, the disease resumes its activity. I was told of the effort having also been made to force the bushes by heavy plucking, but without any beneficial result. Usually the planters have assured me that, while they knew the bushes were useless, nothing short of uprooting could be of any use, and, to propose to uproot such a large number of plants, would be to court a severe rebuff from their owners. There was nothing for it, therefore, but to cultivate the ground around these sulking useless bushes, to prune them at the same time as the others, and to be content with such returns as could be obtained from them.

SULKY.

Not Recognised by the Planters as a Disease.

Severe Pruning and Plucking a Failure.

Uprooting.

763. Description.—The above remarks may, I trust, suffice to bring to mind the disease to which I here allude, for not only are the bushes being slowly killed by a pest, but by one that fortunately will yield more readily to treatment than almost any other in the tea garden. The following descriptive account of the form met with in Ceylon will be of interest to the Indian planters: "This species," writes Mr. Green, "feeds on the flush: the living insects can be found only upon the bud and the under sides of the two following leaves. As each bud opens, the colony moves higher up, deserting the older leaves. But these latter are permanently injured, and always retain the marks of the disease. The distinguishing sign is a roughened surface and brown stain extending for some way on each side of the midrib; sometimes covering the whole of the under side of the leaf, but generally confined to the central portion. Sometimes again, there is a brown crease between the margin of the leaf and the central diseased part looking like a supplementary rib on each side of the median one. This crease results from the attacks of the mite upon the unopened bud, while the edges of the leaf are still folded inwards. The diseased leaves never attain their full size; they lose their natural gloss, become hard, puckered, and give

Mite Found on the Bud and Young Leaves.

Leaves Permanently Injured. *Conf. with paras. 603, 605.*

Brown Stain on Underside.

Arachnoidea (Acarinæ).

ACARUS, SP.

Bushes Become Smaller.

an unhealthy appearance to the whole bush that is very noticeable. After a prolonged attack the bush becomes smaller and smaller with little spaces between the leaves; and finally the tree refuses to put out flush shoots."

"The individual insects are so minute as to be invisible without the aid of a magnifying glass. Under a good microscope they may be distinguished, in all stages, crowded upon the youngest leaves at the tip of the shoot."

Young Mite.

"The young mite has only six legs and is of a sluggish disposition. It is of a very pale-yellow colour with clouded whitish stripe along the middle of the back. It seems to undergo only one moult before assuming the perfect stage." "The adult female is of a clear amber colour, with a smooth glistening skin, and with a clouded dorsal stripe, as in its larval stage. It has now an additional pair of legs, but this fourth pair is carried, apparently, more for show than use. They are much thinner than the others, and terminate in two bristles of unequal length." "The male is so unlike both the young and the adult females that I should have thought it to be a distinct species had I not myself witnessed its transformation from the larval stage. It is of the same colour as the female, with the same clouded dorsal stripe, but it is of a very different build. Its legs are more powerfully developed. The hindermost pair, though not used in locomotion, are stouter than the others, and probably act as clasping organs. They are armed with a strong curved tooth on the inner margin, and a long whip-like bristle on the foot. The six locomotive legs each terminate in a bilobed pad, and the first two pairs bear a knobbed bristle upon the outer margin."

Adult with a Useless Fourth Pair of Legs.

Male Mite.

Extent of Distribution.

764. ***Depredations and Extent of Distribution.***—The following passages from my diary may help to more fully exemplify the nature of this pest, and manifest the extent to which it is distributed :—

Khumtai.

765. *Khumtai, 7th April 1895.*—Several bushes, seen with the leaves dark green, crumpled and wavy on the margin, the upper surface being puckered, for a certain distance on either side of the midrib, a condition that corresponds to a felted coating below, similar to what is commonly seen on the leaves of the cotton and many other plants. Similar formations were formerly described as species of fungi, under the name of Erineum, prior to their being proved to be epidermal growths caused by the irritation of mites. Failed to discover the mite, and as there were no young buds, presume the

leaves examined show the after-effects of last year's depredations of a mite that may probably return later on in the season. (*No. 10497.*) **SULKY.**

766. I had the pleasure of a walk through garden and a conversation with Mr. G. on the 12th April. I pointed out to him the disease I have provisionally called the Apple-foliage blight. Many plants were seen to be completely destroyed by it, and others not flushing, and with the young twigs that had appeared covered with the pink scale-like formations characteristic of this remarkable disease. It is by far the most serious visitation in this garden. In an area of 20 square yards, as many as six diseased plants were counted. These had formed no new leaves since pruning, and every bud and leaf present had been thickly coated with the scale-like tomentum. The young shoots had been killed (no fresh shoots visible), otherwise plants were healthy and well formed. They had the appearance of having been severely and suddenly arrested in their growth. The specimens collected show the ultimate stages in which the tips of the branches indicate a continuous interruption to the formation of shoots, the shoots having been dwarfed in bud. **Nazira.** **Bushes Arrested in Growth.**

The percentage of death from this cause seems very high. In the very finest part of the garden where the bushes are seven years old, and perhaps 4-5 feet in diameter (never collar pruned) and stems healthy, there might be 2 per cent. killed outright, and in some places even more. Not one of the bushes still alive have produced a leaf since they were pruned last autumn, and a very large number of bushes were seen in this latter state. Though I examined them with the utmost care, I could not find any of the mites that I presume to be the cause of this stunting of the plant and felted condition of the leaves. **Mite not Seen.**

767. *Ligri Pukri, April 14th.*—Showed the manager a fair number of bushes affected with the apple-foliage blight. He agreed to my proposal to collar prune a certain number, fire in the manner proposed by me a similar number, and mark down a third set to be left alone in order to see if they threw the disease off, and to decide whether collar pruning or firing was the better treatment. **Ligri Pukri.** *Conf. with para. 778.*

768. At Atkhel I observed (April 19th) that, plants with the apple-foliage-blight, very generally have the bark and stem just below ground soft and pulpy and of a brown or red colour instead of being of a healthy greenish brown. Suggested that a selection of the plants should be fired and a comparison carefully preserved between these and others left as they are. **Atkhel.** *Conf. with next page.*

In a garden in Jorhat Division, visited 24th April, I found a very large percentage of apple-foliage blight. This was somewhat striking since a few miles off, at Amguri, I practically failed to find an example of this most mysterious of all diseases. **Jorhat.**

In new plantation about one per cent. of the three years old bushes had the apple-foliage blight, none of the old ones had it.

Arachnoidea (Acarinæ).

ACARUS, SP.

769. At a garden visited on the 25th April in the Jorhat Division, a fairly large percentage of the apple-foliage-blight was seen in new plantations, less in the old.

At Jorhat on the 26th April, I saw many samples of apple-foliage-blight, the bushes in all stages of decay, and many dead. The disease was in fact extremely prevalent.

Moaband.

770. At Moaband, April 28th, the bushes affected with the apple-foliage-blight, showed the buds aborted, all the leaves having fallen off. In consequence short distorted leafless buds were found amid last year's large leaves, but no flushing shoots. The aborted buds were seen to be densely coated with rufus scales similar to those on the leaves, but the mite, which I presume to be the cause of this diseased condition, could not be found. (*No. 11331.*)

Nigiriting.

771. At Nigiriting, May 2nd, the apple-foliage-blight was found fairly plentiful, in the older portions of the garden. At my suggestion a large number of the bushes were to be fired as the best remedial measure. (*No. 11991.*)

Dum Duma.

772. At Dum Duma, Dibrugarh, June 27th, a few bushes found with the apple-foliage-blight. (*No. 11929.*)

Makum.

773. At Makum, I found three plants with the apple-foliage-blight and one which might be described as a seedling. This garden is now (1895) only four years old, and is perhaps 20 miles distant from any other garden.

Panitola.

774. On the 18th June, while on visit to Panitola and neighbouring gardens in the Dibrugarh District, I found the apple-foliage-blight to be rare. While showing this disease to some planters I was handed a letter from Mr. Gair, of Atkhel (Sibsagar District) in which he informed me that the bushes with apple-foliage-blight that had been burned at my suggestion, on the 19th April, had flushed freely, far better in fact than the others, that as a parallel experiment had been severely pruned. Further that they showed no signs of a return of the blight. Burning, therefore, would appear to be a most effectual cure for this very remarkable disease.

Bordeo Bam.

775. July 5th, Bordeo Bam, North Lakhimpur, came across a slightly different form of the apple-foliage-blight. All the twigs and shoots were densely covered with rufus scaly tomentum. This extends up the peteoles and often covers the whole under surface of the leaves. In other cases the leaves show two diverging lines of scaly tomentum extending from the base to the apex of the leaf, similar to that produced by CEYLONIA. The plants were entirely arrested in their growth, and even to present date had thrown out no new flushing shoots. Could find no insects or mites on the leaves or branches nor in the buds. (*No. 11946.*)

The Apple-foliage Blight.

July 6th-8th, Patalipam, apple-foliage-blight known, but not very abundant. **SULKY. Patalipam.**

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776. REMEDY.—Mr. Green says, "Excepting the bark-louse (**Aspidiotus**, No. 72 above), I consider this 'Yellow Tea-mite' to be one of the most serious pests we have to deal with. Protected as it is by the downy hair that clothes the under surface of the young leaves, it is unaffected by heavy rain and continues its ravages uninterruptedly throughout the year. As it is confined to the flush, the persistent plucking of every shoot on such diseased trees, ought to remove the cause of the disease. The flush is usually so hard and *banjhi* that it is apt to be passed over by the pluckers. After pruning one of these 'Sulky' trees, the prunings should be at once removed and destroyed. In fact I think the systematic destruction of all prunings *while still green*,—either by burning them *in situ*,—or by removing and burning them—would of itself prove an immense check to the insect pests of all kinds."

Continues its Ravages Throughout the Year.

Persistent Plucking.

Burning Prunings.

777. From what I have stated of my failure to find the mite, from April to June, it may, I think, be accepted that in India this mite is not in activity throughout the year. It is probable that it may exist within the unexpanded buds (during the months named), but, if external, it must be very few in number. In this respect, then, the Indian mite differs from that of Ceylon. But its depredations are evidently so serious, during the months of activity, that it takes some time for the bushes to recover. In Ceylon, Mr. Green informs me, pruning can be done any month during the year, and that accordingly this pest can be dealt with by delaying the pruning to the season at which the entire affected branches and shoots may be removed. To treat the Indian plant on that plan, pruning would have to be delayed till August very possibly, and might then prove fatal to the bush. It was on these lines that I reasoned out that there were two possible methods of treatment, *viz.*, (*a*) to collar prune all bushes affected by this pest, and to at once burn the prunings, or (*b*) to fire the affected bushes, say, in March. The latter course I recommended to many planters, and in the extracts from my diary above have already mentioned the result obtained in one experiment. The bushes were entirely freed from the pest, and flushed freely very shortly after. While in the Dibrugarh District I mentioned this fact on several occasions, and one planter tried the experiment on two bushes, both

Depredations Serious.

Pruning as a Remedial Measure.

Fire the Best Method. *Conf. with paras. 641, 649, 767-8, 774, 778.*

Arachnoidea (Acarinæ).

ACARUS, SP.

Firing Should be Done in Spring.

died. But he fired them in June and thereby confirmed an opinion that I had freely urged, that fire, as a treatment for pests on tea, must never be resorted to during the time the sap is circulating freely. If that restriction be neglected, the shock to the plant is so severe that, if it be the least sickly, it will, in the majority of cases, be killed.

Report of Results with Firing.

778. In the passage from my diary (quoted above, *page 397*) regarding Ligri Pukri, it will be seen I proposed a comparative trial, with one set of apple-foliage-blighted bushes to be fired, the second collar pruned, and the third marked for comparison with the other two sets. The following report was subsequently furnished by Mr. J. A. Thomson :—"The apple-foliage-blight experiments are going on all right. The plants that were burnt sprouted away much faster than those collar pruned, and the shoots are strong and show no signs of disease, but, if the plant required collar pruning at any rate, I would prefer to use the saw, and only burn those that had been collar pruned already. I burnt bushes that had been collar pruned some years ago all over the garden, here and there, and the result is very satisfactory. I fancy for one thing that the ashes from the stuff used for burning acts as a manure. The bushes not pruned nor burned, are just managing to live, but have not given a single leaf fit to make tea."

Collar Pruning.

Certain Cure.

779. It will thus be seen that, if bushes affected with this most destructive pest are marked out to be collar pruned in Spring, where that is considered desirable, or fired where collar pruning is not necessary, we possess a certain cure. No tea garden in Assam need have a single bush "sulky" and unproductive from mite infestation, if the suggestion here offered be accepted. The few bushes that may die were worthless, and the space they occupied should be regarded as more valuable than their presence. In my opinion firing is peculiarly applicable to this pest.

When the apple-foliage-blight appears in the nursery, the treatment suggested by Mr. Green for the purple-mite should be pursued (*see page 392*).

96. (c) Phytoptus theæ, *sp. nov.*

THE PINK-MITE.

(*Reg. No. 67.*)

PINK-MITE

Conf. with paras. 49-50.

780. HISTORY.—During my explorations in 1895, through the chief tea districts of Assam, I was taken to a clump of tea supposed to be

badly attacked by green-fly. Instead, however, of the leaves being dark green, erect and folded or crinkled in the peculiar manner said to be characteristic of green-fly, they were very pale-coloured, almost white, dry, convex above, with the margins and veins of a pink colour. In what could at once be seen as an advanced stage, the leaves were almost bronzed, from the extension of the pink tinge over larger portions of the leaves, but they did not appear to wither and fall off the bush.

THE PINK-MITE. Leaves Pale Coloured, Ultimately Bronzed.

781. A little examination sufficed to reveal these plants as suffering from a pest with which I was then unfamiliar, but which was clearly quite distinct from green-fly. Under the lens the leaves were observed to be covered with thousands of a very minute mite which, in the adult state, was of a pink colour, hence the pink tinge to the leaves. These mites were further noted to be most abundant on the margin and along the line of the veins. Though very abundant on the upper surface of the leaves, they were also found below. But it was curious to observe that about one in every hunderd or so was of an entirely different shape and of a purple colour. The latter I subsequently identified as a distinct species,* though met with in association with the pink-mite. The association of two or more minute pests together, is one of those extremely difficult problems that seem almost incomprehensible. This is peculiarly troublesome in the study of scale-insects and mites, in which very nearly invariably two species are found in intimate association and have repeatedly been mistaken as the males and females of one species, instead of being two entirely distinct forms.

Mistaken for Green-fly.

Two Species in Association. ***Conf. with page 390.***

782. Description.—Seen under a fairly powerful lens, the adult pink-mite is a linear oblong creature, broadest near the head, and gradually tapering to the tail. It may be described as being about 100th part of an inch in length. It walks about in a curious attitude, with the head carried at a higher level than the tail. In moving it also twists its body, being apparently aided in progression by a sucker-like process at the anal extremity. The legs are two pairs, placed in the front of the head and directed forward. They are three jointed and have two minute hairs at the joints. Under the microscope the body seems to consist of four sections, one a somewhat

Adult Mite.

Position and Number of Legs.

* **Typhlodromus carinatus,** *Green.*

Arachnoidea (Phytoptidæ).

PHYTOPTUS THEÆ.

Description of the Mite.

triangular terminal portion that may be designated the head. The next two are sections of the body proper, and the fourth the anal extremity. This is furnished with what appears to be a retractile sucker, by which the mite can fasten to the leaf and raise the other portions of its body, jerking and propelling its self about. But it would seem as if the entire body were made up of a large number of folds which, seen on the outer circumference, give the appearance of a toothed margin. Down the centre of the body a faint line is discernible which near the middle of the two central divisions swells into a circular spot. The mouth seems to consist of two mandibular processes with two antennæ-like feelers in front. The sketch made from the live insect, Fig. 11, will convey some idea of its structure.

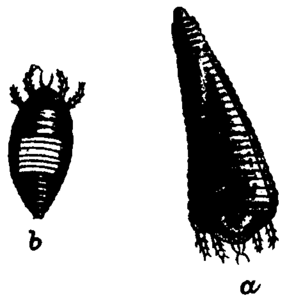

FIG. 11.—THE PINK MITE.

Immature Mite.

783. The immature mites or larvæ (*b*) are more elliptic in shape and tapered to both extremities. At first they are almost pure white and hyaline. With age they become coloured, the second and fourth sections of the body being darker coloured than the first (or head) and the third or central section. But even in their earliest stages they manifest the peculiar folds of which each section of the body appears to be built up. They seem to molt in the usual manner by throwing off one or two skins before they attain the adult condition.

Absence of Eggs.

784. A striking peculiarity of the colonies of this mite is the entire absence of eggs. With the red-spider, on the other hand, what catches the eye almost before anything else, on viewing a red-spider-infested leaf through a lens, is the immense number and extreme beauty of the eggs, cemented all over the upper surface. But with the pink-mite the margins of the leaf will be observed to be thickened and even warted for some distance inwards. These warts or blisters are doubtless the breeding chambers within which the eggs are deposited and apparently also the houses of refuge for the young larvæ. Unfortunately, when travelling in Assam, I could not carry with me full microscopic apparatus, more especially a section cutter

Warts on the leaves.

so that I was not able, when fresh material was in my hands, to fully investigate the structure of the mite and its method of reproduction. The specimens preserved in spirits of wine have suffered so severely that even the mite itself cannot now be recognised with any certainty. I believe, however, that I am correct in suggesting that this mite is a species of **Phytoptus,** and that, like all its congeners, it is a felt-gall-forming mite not very remote from **Phytoptus pyri** and **P. ribis,** the blister mites of the pear tree and of the blackberry bush. **PINK-MITE.** **Felt-Gall.**

785. DEPREDATIONS.—In the introductory chapter of this report, *pp. 29 to 31*, I have already alluded to this pest. I have there stated that it has largely to account for the pale colour and late flushing of some of the finer *jats* of Assam indigenous tea. I never came across it on the China plant, nor even on hybrids, unless of good quality, and it would appear to be rare on the Manipur *jat.* Apparently it is most frequent on light sandy loams, and prevails to a greater extent during dry seasons than in moist weather. It accordingly occurs early in Spring and gradually disappears as the rains become established. When present to any serious extent, it retards the flushing for several months. But the leaves do not turn brown and drop off the bushes as with the purple-mite. It is more widespread and more frequently present, but is less epidemic (so to speak), and accordingly attracts hardly any attention, as compared with the purple-mite or red-spider. But, I believe, the loss through this insidious pest is far greater than the majority of planters have any conception of. I am not likely to forget the reception I got from the late **Mr. Madden,** of Panitola. "We are delighted to see you," he said, "but have no pests or blights to show of any consequence." Have you not, was my reply, then what is the matter with this expanse of pale yellow-green plants all around us? "Oh that is not a disease, but a proof of the high quality of the stock. It is the very finest Assam indigenous, which, you know, is very much paler coloured, and later in flushing than the other *jats.* In a week or two it will be in full bearing and a magnificent crop may be anticipated." On being shown a leaf, through my lens, literally alive with the pink-mite, **Mr. Madden,** to my question whether these visitors were likely to be hurtful to the plant, at once admitted that they must injure it materially.

Pale Coloured Leaf and Late Flushing. *Conf. with para. 49.* **Retards Flushing.** **An Insidious Pest.** **Proof of high Quality.**

Arachnoidea (Phytoptidæ).

PHYTOPTUS THEÆ. One of the Most Serious Pests of Assam Jats.

786. I have taken the liberty to publish the above conversation (from my diary), because I think that, had Mr. Madden been alive to permit me to do so, his reply would have been, that it was as well that the reputation of pale colour and late flushing should be pointedly demonstrated to be in many cases, but the direct expression of a serious visitation—one of the most serious perhaps to which the indigenous plant is exposed.

As manifesting the very widespread distribution of this pest, I may give here the following passages from my diary :—

Nigiriting.

787. While investigating the question of green-fly at Nigiriting on 1st May 1895, I observed that the young leaves often stood erect; that they might be described as folded lengthwise ; that the tips were bent over ; and that in many cases the margins were inflexed. But what was still more curious, the midrib and veins were pink, while the general colour of the leaves might be spoken of as pale greenish-yellow to almost white, the pinkish tinge giving them a bronzed effect. On examining these leaves closely I saw that the margins, midrib and veins were pink mainly on the upper surface. Under the lens this pink colour was soon discovered to be due to the presence of immense multitudes of a very minute pinkish-coloured mite which, when magnified 40 diamaters, was not larger than the point of a needle. It is of a conical shape, pointed towards the tail end, and seemed to walk with its truncated extremity forward and slightly elevated.

Blister Mite.

This creature I have not as yet had time to examine with the microscope, but it looks remarkably like one of the blister mites, and thus possibly allied to the pest on the pear, and other fruit trees in Europe and America. But on making this discovery, an idea at once struck me as being of some moment. I had been taken to this particular plot in order to be shown green-fly. That insect could undoubtedly be found, but the bent leaves with reflexed margins and the unhealthy state generally, pointed out as indicative of the approach of a bad attack of green-fly, were much more likely to be a consequence of this hitherto undiscovered mite, than to be caused by green-fly. Could a mistake have been made by all previous observers, for I had seen stunted blight without green-fly, and green-fly without any stunting of the bushes ? This point would have to be carefully investigated, but I here repeat that green-fly was found freely on the leaves on which this new mite occurred in thousands almost on each leaf. Of one point I had no doubt, (as soon as I had seen this mite), namely, that it at all events was the cause of the blanching and bronzing of the leaves. But the stunted blight, in its advanced condition, (which I had previously examined), presented many peculiarities not observable on the mite-infested plot. The two could, therefore, quite easily be independent of each other, though the early stages of green-fly stunting, might be often confused with the blanching due to this new tea pest.

Possible Confusion with Green-fly.

The Pink-mite.

PINK-MITE.

Mr. Holmes, the Superintendent, to whom I demonstrated, by means of a powerful lens, the presence of this little creature, remarked that those seen on the leaf looked, when so magnified, like a great flock of sheep grazing over a large field. He was, however, so much disappointed with the sickly-looking white bushes, in this part of his estate, that he took me off at once to see a new plot of tea, laid out with Manipur seedlings, where he assured me, all the bushes would be found of a dark enough green to satisfy my utmost desires in that direction. He was, however, amazed, as we neared this particular plot, to find that, since the date of his last visit (and for the first time to his knowledge), all the bushes had turned pale greenish yellow. This I very soon demonstrated was due to my new mite, and we were both of us thus convinced a discovery of great value had been made that no doubt would account for the late flushing of many gardens.

Found on Manipur Jat.

In Golaghat.

In a garden visited on the 2nd May (in the Golaghat Sub-Division), I found yellow leaves with the new pink-mite common, and the bushes so affected showed green-fly in addition.

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788. On the 2nd May, I also examined an extensive plot of the very best Assam indigenous tea with the flushing arrested and the leaves all turned pale yellow. As anticipated from experience lately gained, it was to be expected that the leaves would be found covered along the margin and on the midrib upper surface with multitudes of the minute pinkish-coloured mite. These were observed to move about fairly actively, and to eat the minute hairs and epidermis of the leaf. They are so small as to be absolutely unrecognizable to the naked eye, except through the colour they give to the parts mentioned.

Purple-mite.

Here and there, amid multitudes of pink-mites, a few dark purple ones were to be seen, with three white bands down the back (**Typhlodromus carinatus**), and a very large number of still more minute larvæ, but no eggs. The pink-mite has a triangularly pointed head portion, and the rest of the body referred to three distinct sections.

Warts on the Leaves.

I have not had the time to attempt to trace out the life history of this mite, but it appears to originate from wart-like thickenings on the leaf, which possibly correspond to caverns within the tissue. It is, in other words, probable that the eggs are deposited within the tissue of the leaf and possibly through the stomata, and that the blanching of the leaf is largely due to this circumstance. The breathing functions of the leaf would thereby be interrupted, and the young leaves hardened and dried up as if they had become prematurely old.

The hardened, curled-up and bronzed leaves, undoubtedly, have been taken by many planters as caused by green-fly. I have had this fact repeatedly verified, since I first detected the mite, and that too in many gardens, where the planters, on being challenged, failed to produce a single example of green-fly in support of their statement that their gardens were suffering from that pest. When these mites

Arachnoidea (Phytoptidæ).

PHYTOPTUS THEÆ.

Margins of Leaves Inflexed.

are on the leaves, the margins are inflexed (that is to say, turned over the upper surface), rarely reflexed. They stand up in the way attributed by planters to green-fly, though in this ascending attitude it, is generally affirmed the green-fly-infested leaves are of an exceptional dark colour. If that be so, then we have one marked difference between the two pests.

Nazira.

789. On my return to Nazira on the 11th June, I found the pink-mite very abundant, especially on some reclaimed land. It was not so abundant, as recorded, further down the valley, but doubtless that was due to the rains having been fairly established, by the date of my return visit. The plot on which I found it, was backward, owing possibly to the severe pruning on its being reclaimed. The contrast between this yellow-leaved sickly portion and the rich green of the adjacent healthy parts was very striking. Both the pink and purple-mite were found, though the latter was extremely rare.

Panitola.

790. At Panitola I found a large percentage of bushes yellow and with red margins. The pink-mite, though seen on these, was not so abundant and active as in other gardens earlier in the season. I infer that, as in Ligri Pukri, this pest is passing off, and that its period of activity is but short, possibly 6 to 8 weeks at most, extending from about the middle of April. On June 18th, I was driven by Mr. Madden all over this large estate. We found yellow foliage due to mite very prevalent, especially so on some young tea raised from Singlo seed. This is a fine *jat* of tea with a rich soft foliage that flushes freely and has moderately-sized leaves, but it would appear to be very liable to this mite. Many of these pale-foliaged bushes were also found to have transparent thickened patches all over the leaves, and these turn into pinkish brown spots. Whether these were caused by the pink or the purple-mite I was unable to determine. The bleached and bronzed bushes looked very unhappy, and unwilling as it were to respond to the showers of rain that had caused other portions of the garden to flush freely.

Makum.

791. At Makum on the 21st June, I found a fair percentage of plants (Tingri stock) of a pale yellow colour and with pinkish margins and veins. Only a few of the pink-mite were, however, visible, though the purple form with three white longitudinal waxy lines was plentiful. This circumstance would seem to point to the two forms being distinct. This estate (in 1895) was only four years old, and no other garden (until quite recently) within a radius of 20 miles. It was, therefore, difficult to understand how the pink-mite had got there so quickly.

I also found in another part of the garden that an immense number of bushes had bronzed leaves, as if from red-spider, but that, on the under surface, countless numbers of minute white empty cases were observed, much smaller than the mite mentioned, and consequently infinitely smaller than the empty cases of red-spider. As these bushes were not known to have had red-spider, it seemed

probable that they had been attacked by, perhaps, the purple-mite by itself, that is to say, not in association with the pink-mite. If this supposition be correct, the attack may be supposed to have passed off, the more so since rain had been falling for some time. PINK-MITE.

At Tingri visited on the 26th June, I found pink-mite, though evidently the attack was passing off. Tingri.

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792. This mite was found quite active in Patalipam, North Lakhimpur, July 8th. The leaves of the bushes affected manifested all the peculiarities already detailed as characteristic of it. Mr. Lindsay Alexander had often observed the arrested growth, pale and bronzed foliage, but had never, until now, seen the pink-mite. He no sooner had it pointed out to him, than he freely admitted it was the undoubted cause of the conditions referred to, and accounted for a heavy loss due to the late flushing of plots so affected. Having had a little more time at my disposal at Patalipam (where I was, so to speak, a prisoner through the rise of the great Subinseri River) than during my forced marches through the tea districts, on the south side, I got out my small field microscope and examined this mite with some care:— Patalipam. Heavy Loss.

It was found to have two pairs of legs, each of three joints and with minute hairs at the joints. All the legs are directed forward, lie underneath what may be called the head, so that the rest of the body appears to be dragged and pushed along. The young ones are much smaller than the adults, are oblong, elliptic and only slightly tapered towards the tail. In colour they are white hyaline, the body apparently consisting of three sections and the head. Middle section paler coloured than the other two. As they get older they become more elongated, loose their elliptic shape, and become obovate oblong and pink coloured, with the first and last sections of the body more deeply coloured than the middle or than the head. Surface of the body marked by many transverse folds (10-15 in each section), thus giving the appearance (when seen from above) of a minutely crenated marginal rim. I was unable to discover the mode of reproduction, and was much surprised with the fact that I failed to find in Patalipam any of the purple elliptic associate of this mite, which I have already described as having three longitudinal waxy lines down the back. I now believe that the two are distinct species, and that the pink-mite is an undescribed species that in many respects recalls the PHYTOPTIDÆ. Description. Purple-mite not Present.

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793. At Gopesadarhu visited on the 12th July, the pink-mite was found to be still vigorous, but no example of the purple form with white bands was seen. The pest was thought to be disappearing for the present season. Gopesadarhu.

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794. Bor Phukuri, visited on the 12th July, showed Mr. W. A. Harry the pink-mite. It was found on good *jat* Assam which had been Bor Phukuri.

Arachnoidea (Phytoptidæ).

PHYTOPTUS THEÆ.

pruned in January. The leaves were pale yellow mottled and covered with the mite, both forms being present.

Mijika Jan.

At Mijika Jan visited on the 13th July, pink-mite was found very common, especially on the better Assam teas and late pruning.

Seconee.

At Seconee (visited 18th July), I found the pink-mite on good *jats* Assam indigenous.

795. Remedy.—There is very little that can be said under this heading. By most planters this is hardly viewed as a blight. The leaves do not fall off, and they even recover colour with the rain. It simply retards the flushing, and in some estates to no very serious extent. There is no doubt, however, that it must weaken the bushes. An observation made by me of the live insect kept for some hours under the microscope, seemed to point to its eating the hairs off the leaf and biting the guard cells of the breathing mouths. Leaves badly blighted seemed to have the stomata abnormally open. Even therefore, should the flushing be not delayed to the extent to cause anxiety, there can be no advantage in allowing this pest, year after year, to infest the bushes for a month or two at a time. The treatment mentioned above for the purple-mite would, be perfectly applicable to this species. I should at all events strongly recommend test experiments to be performed on selected plots, the one being two or three times thoroughly syringed with Adhatoda infusion or kerosine emulsion, and the other left alone. The treated portion should not only flush quicker, but throughout the season manifest greater vigour. Where the pink-mite prevails to an alarming extent, the treatment suggested should be energetically pursued. In other words, I am convinced that, even when present to a small extent, this mite causes a considerable loss, and injures the plants materially. Where present to a large extent, there can be no question as to the imperative necessity of definite steps being taken to secure its eradication.

Eat the Hairs of the Leaf.

Stomata Abnormally Open.

Test Experiments.

CHAPTER XVII.

VEGETABLE PARASITES OF THE TEA PLANT: THE BLIGHTS.

796. It will be recollected that I have imposed a somewhat arbitrary restriction on the words "Pests" and "Blights." The former I have assigned to all the parasitic manifestations of an animal origin, and the latter I now propose to employ as denoting the depredations, effected by parasitic plants. There doubtless would remain a third series of ailments that should be designated *The Constitutional Diseases of the Plant.* These I have treated as predisposing influences to the ravages of pests and blights. They are very largely brought about by imperfect methods of cultivation, by over-production, and by age. The Chapters that deal with Weeding and Hoeing, Drainage, Pruning, Plucking and Manuring, have been written with the view to exhibit some of the more readily recognised directions of possible improvement. They by no means exhaust that theme. Had space and time admitted, other Chapters might have been written on The Selection of Site, The Laying out of an Estate, The Nursery, Transplanting and Seed-at-stake, Filling up Vacancies, Top Dressing with Fresh Soil, Trees and Weeds that are Useful or Injurious to the Tea Garden, etc. But the remarks that have already been offered may be accepted as at least justifying the opinion that the time is more than fully arrived when attention should be turned from the Factory to the Garden. The progress made within the past twenty years, in the manufacture of tea, may be said to have given to India and Ceylon their supremacy over China. It rests with the rising generation to preserve that industry by devoting a large share of their attention to improvements in cultivation. If they do not do so, the result may be more disastrous than anything hitherto experienced in tropical agriculture. The enumeration, furnished above, of the animal pests of the tea plant is by no means exhaustive. The brief historic sketches given under each of the more important forms, point conclusively to two facts, (*a*) that hardly any of these pests were known much before 1870, and (*b*) that the rate of increase both in number of forms and extent of distribution has run parallel with the modern

Constitutional Diseases.

Attention Should be Turned from the Factory to the Garden.

Supremacy Over China.

Important Lessons.

BLIGHTS.

enhancement of acreage production and quality of tea. And the same inferences, it may be added, have to be drawn from a study of the vegetable blights.

797. Unfortunately the time at my disposal, while in Assam, was too limited to permit of an exhaustive enquiry into the subject of the vegetable blights. And to work up even the material collected, might take several years. In presenting the present chapter, therefore, I desire that it should be regarded as but indicating the very extensive field of future enquiry that remains unexplored. While I shall attempt to specialize a few of the more readily recognised Fungal and Algal blights, it is probable that a complete enumeration of all would be very nearly as extensive as that of the pests. The more important vegetable parasites may be said to be two or three fungi found on the leaves; a fungus and also an alga on the stems; and one or more species of fungi on the roots. These blights at least demand careful study, since each may be spoken of as quite as dangerous as any of the pests already dealt with. But before taking them up, it may be as well if I dispose of one or two unimportant enemies of tea cultivation, that fall within this Chapter of Blights.

Chief Vegetable Parasites.

PARASITES.

Conf. with para. 83.

97. (a) Loranthus, *sp.*

798. Two or three species of these parasites are found on the tea plant mostly in the seed garden. During the time of my visit to Assam they were not in flower, and I was thus unable to determine them specifically. They are, like their near relative, the misteltoe destructive parasites that sap the life of the plant. Fortunately they are easily recognized and should instantly be removed. I have seen some seed gardens with every alternate bush or so bearing two or three great clumps of **Loranthus.** It is a serious mistake to allow these to grow, since they must weaken the plants and injure the seed.

Weaken the Plants and Injure the Seed.

The tea plant is peculiarly liable to this class of parasites. In a correspondence regarding tea in Burma (published in *The Agricultural Ledger No. 27 of 1893*) it will be found that a species of **Loranthus**, there known as *chibaung*, is spoken of as killing the tea. This no doubt would be the final result with any **Loranthus** if left to itself.

799. Remedy.—Saw off the branch bearing the **Loranthus**, and coat the wound at once with the Gondal paint (*see page 363*).

98. (a) Ferns and other Plants within the Bushes.

FERNS. *Conf. with paras. 93, 95.*

800. In Kangra, a species of **Euphorbia** introduced from America (*viz.*, **E. heterophylla,** *L.*), has proved troublesome as a weed growing within or around the tea bushes. This I did not meet with in Assam, but in several gardens found two or three species of ferns and occasionally one or two other plants growing within the bushes and doing them considerable injury. *Ulu* grass is specially destructive to the tea when it gets a footing in a garden. These and such like should, however, be rather viewed as indications of neglect than as pests or blights. While I strongly advocate that, for certain seasons of the year, a coating of herbaceous weeds would not only do no harm, but, on the contrary, much good, there can be no two opinions as to the fact that weeds within the bushes themselves are most injurious. They rise up and choke the tea and their roots interfere with those of the tea plant.

Remedy.—Hand-pick and remove every plant found within the tea bush.

99. (a) Lichens and Mosses.

LICHENS. *Conf. with para. 11.*

801. Old bushes and those growing in localities with too much shade and imperfect ventilation or defective drainage, become coated with lichens and mosses. The stems are often spoken of as "hide bound," and the lichens are pointed to as the cause. They are in reality the consequence, but not the cause, of the condition complained of. In the majority of cases it will be found that age is the chief cause of the hide bound condition as also of the coating of lichens, mosses and other epiphytic growths. So long as a plant is vigorous and its stem constantly expanding in circumference, lichens will make little headway. Let its activity decline from age, unfavourable surroundings, or disease, and it will immediately harbour lichens and mosses. The chief insect pests that favour the growth of these epiphytes are the scale-insects. When plant-lice infest the bush, insignificant though they appear, they instantly commence to check its activity. The bush becomes unkempt and untidy. Its leaves are rapidly besprinkled with sand and mud, they turn black through the growth of fungi (soot blight) that feed on the sugary exudations of the insects, or they may be seen to support a botanic garden of beautiful and varied forms of mosses, lichens, liver-worts, fungi and

Hide Bound.

Scale Insects.

Soot Blight. *Conf. with paras. 837-8.*

PESTALOZZIA GUEPINI.

algæ. The bark is seen to split in all directions, to be dry and useless, and to bear a copious coating of lichens and mosses, or to protect the female scale-insects that nestle beneath and are in fact the cause of the bark being split and torn from the stem.

Not Parasites.

802. Lichens are not parasites. They attach themselves to plants, stones or other objects in order that they may secure certain advantages of exposure to the air and protection from unfavourable circumstances. Thus, for example, the stems of palms growing in open positions will be found lichen-coated on the lee side to the point of greatest rainfall of the locality. Lichens are epiphytes, that is, they live on the air and attach themselves to the surface of plants, without materially abstracting anything from them.

They are Epiphytes.

803. REMEDY.—To cure the plants so infested, the cause must be discovered and the treatment regulated accordingly. If the land be imperfectly drained, that must be corrected. If the jungle be too near, or the ventilation defective, a clearance must be made by cutting openings in the forest to allow of a freer circulation of air. If age be the cause, collar pruning would very possibly renew the garden, and for a time allow of enhanced returns, ultimately a point would be reached, when, in my opinion, nothing further can be done except to uproot and replant. But should the cause be a severe outbreak of bark or leaf-louse, the surest and most effectual remedy will be found in firing the plot. This should be accomplished early in Spring, then light prune a fortnight later, and, while pruning, wash or brush the stems and branches with lime, to remove all the charred lichens, mosses, and other adhering matter. (*Conf. with the foot-note, p. 6.*)

LXX.—Leaf Parasites or Blights.

Conf. with paras. 39, 41.

100. (c) Pestalozzia Guepini, *Desmaz.*

GREY BLIGHT: *by some planters called* DRY ROT.

References.—*Desmazieres in Ann. Sc. Nat. Ser. II. p. 183; Diseases of Plants by Dr. Karl Freiherr von Tubeuf, (translated by Dr. W. G. Smith), p. 494.*

(*Reg. No. 134; botanical specimens Nos. 11903, 11930, 11933, 11934, 11938, 11947, 11948, 11967 and 11969.*)

Appeared Ten Years Ago.

804. HISTORY.—So far as I can discover, this blight has appeared within the past ten years or so at most, and was first seen in the Dibrugarh District. It then crossed the river to the north bank gardens and extended right down to Tezpur; it also recrossed to the south at

Grey Blight.

Nowgong. So far as Sibsagar District is concerned, I only met with it in one garden and on a few bushes. Since the date of my explorations I am led to believe, however, it has appeared very bad in one or two gardens in Jorhat. Although met with on all *jats* of tea it seems to show a preference for the China plant and low class hybrids. **GREY BLIGHT.**

805. In Europe it is a well-known blight on **Camellia, Citrus, Magnolia, Rhododendron, etc.,** but, until discovered by me on the tea plant, was not known to occur in India. Recently I received a sample of tea affected with it from Cachar, and **Mr. E. E. Green** has kindly furnished tea leaves infested with it, so that this blight occurs in Ceylon, as well as in Assam and Cachar. It is, therefore, highly probable that it exists in all the other tea districts of India, but I may add it was not found by me in Kangra. **Found in Cachar.** **Found also in Ceylon.**

806. Description.—For the purpose of the present report it will suffice if I furnish a popular description of this very dangerous blight. At first it appears as minute brownish-grey spots on the upper surface of the leaves. These increase in number and coalesce into large patches, which thus come to have an undulating outline. The individual patches will be seen to manifest a slightly thickened rim of a pale greenish brown colour, and near this may occasionally be observed a series of small black warts or perithecia. As the rim widens, zone upon zone of these perithecia are formed until the surface of a large patch becomes methodically spotted with black, over the otherwise smooth and ultimately whitish grey. But the perithecia are, however, only occasionally present, the majority of the leaves will be seen to be simply covered with numerous variously shaped brown and grey patches—some not larger than the head of a pin, others an inch or more in diameter. On the under surface of the leaf, a corresponding portion, to that invaded by the grey patch of the upper surface, will be seen to be discoloured, but to manifest no external formations. It very often happens that these brown and grey patches commence near the base of the leaf, but they may appear on the apex or on the margin, or two or three may form at once and extend until they unite, when the entire leaf may assume a dirty whitish grey colour. Under the lens it will be seen that the grey colour proceeds from the epidermis being raised up from the rest of the leaf tissue, like the loose cuticle over a blister. There is no blister or **Minute Spots.** **Perithecia.** **Under Surface.** **Point of Origin.** **Epidermis Raised.**

PESTALOZZIA GUEPINI.

swelling however, the leaf is of its normal thickness, and, far from being blistered, it will be found that beneath the separable epidermis the tissue of the leaf has been dried up in a peculiar manner, so that it crumbles to pieces and readily separates from the veins on being pressed between the fingers.

Sporules.

807. The fungus proper may be said to reside within the leaf; it absorbs the sap and completely transforms the tissue. Naturally the leaf is thereby killed. The black warts (perithecia) may often be found below the epidermis, even when not visible above. Under the microscope these are seen to be comprised of a number of curiously formed bodies crowded together, each attached by a short stalk. These are the sporules, and, when examined more carefully, will be found to consist of a transparent pedicle, supporting a central black body, (composed of three rather square cells) which bears on its apex hyaline cilia. These sporules may in fact be spoken of as consisting of three dark and two hyaline cells, the terminal hyaline cell having a plume of divergent filaments. The sporules (conidia), or as they were at one time called sporidia, are of course very minute and look on the surface of the leaf like a fine black powder, the particles of which are blown in the wind and communicate the blight all over the tea garden. A peculiarity of this fungus, as met with on different host-plants, may be here mentioned, *viz.*, that it so completely changes its external form that without the microscope it is unrecognisable.

Black Powder on Surface of Leaf.

Leaves Sewn Together.

808. It may also be noticed that the leaves of the tea bush are often sewn together as it were. A diseased one above drops into contact with a healthy leaf below, and where they touch they become cemented by a curious tuft of fungal filaments. I have not as yet been able to establish that this cementing of the leaves is directly connected with grey-blight, since this peculiarity is not universally present; nevertheless it is of so frequent occurrence as to justify the circumstance being mentioned. Many fungi are known to dispense with the production of spores (seeds) and to reproduce themselves indefinitely by mycelia or thread-like filaments. From the circumstance that only a few leaves may be found to bear the perithecia with their sporules, it might be inferred that this blight, by means of the filamentous union of the leaves, was extending its destruction from leaf to leaf and plant to plant, without the production of sporules. I have reason to suspect that diseased leaves borne in the wind adhere

Mycelial Reproduction.

Association with Thread Blight.

to objects with which they come in contact, and thus communicate the blight. But, on the other hand, grey-blight is often associated with thread-blight—a disease that it will be found, from the account given below, most undoubtedly is communicated by affected parts becoming attached to healthy structures. **GREY BLIGHT.** *Conf. with paras. 889 80.*

809. Depredations.—This is one of the most destructive and most dangerous of the parasitic fungi to which the tea plant is liable. It commences for the most part on one side of a bush, very often on the same sides of all the bushes over an affected plot—a circumstance that may be taken as indicative of the germs having been wind-conveyed. It then may work round the circumference of the bush, killing a section of perhaps a foot or more in breadth, or it may gradually ascend and ultimately pass through and over the bush, until every leaf and shoot is killed. On the spots appearing, the leaves gradually become darker coloured, so that the affected bushes may be recognized from a distance; indeed the whole garden may appear to turn brown and grey. As the disease advances, the leaves fall off and collapse on the top of each other, and become fixed within the twigs of the affected part, giving it a very diseased appearance. The blight commences, first of all, on the surface of the bush, so that the dead leaves lie on the top, as the destruction extends down, round or through the bush. But it is a striking feature that it is confined, as it were, to one part of the bush (that is to say, the whole bush is not simultaneously invaded), and it advances but slowly or may leave that bush and pass to another without doing more than killing a space of a foot or two in diameter. Moreover, the blight does not attack every bush at once, but one or two here and a nest of others there; and as the season advances it spreads more rapidly until large plots may be completely destroyed. Unfortunately I only made acquaintance with this blight on the 21st of June, and in less than a month's time had to leave the province, so that I neither saw the early nor the late stages of the disease. I had no opportunity of seeing whether the invaded bushes or portions of them were killed outright, but I was assured that this was so, and that to this disease has to be attributed much of the unshapely condition of many plants, whole sections of them having been destroyed by this blight. It is by no means an usual occurrence to find bushes with holes eaten out of them, as it were, on

Wind-Conveyed. **Bushes Turning Brown and Grey.** **Dead Leaves Lie on Top.** **Often Confined to One Part.** **Is Scattered Over the Estate.** **Killed Outright.** **Holes Eaten out of the Bushes.**

PESTALOZZIA GUEPINI.

would check the spread of the disease, there can be no doubt, since every leaf so destroyed might have extended the malady. Burning in Spring would not injure the bushes, and it would certainly check the spread of the disease, but it is probable we shall not be in a position to lay down definite lines of treatment until the full life history of the fungus has been worked out.

Scientific Report Promised.

815. I am told by **Mr. W. T. Thiselton Dyer, C.M.G., C.I.E.,** Director of the Royal Gardens, Kew, by letter of the 24th January 1896 that **Mr. Massee** has been engaged on the study of this blight, and that his report may be expected at an early date. That report will no doubt prove of the greatest value, in affording a key to the weakest stage in the life of the fungus.

Fungicides.

Bouillie Bordelaise

816. Meantime, it may be recommended that the usual fungicides may be tried. Perhaps the most hopeful would be the *Bouillie Bordelaise* preparation of quick lime and sulphate of copper. The following might suffice for an acre :—

45lb sulphate of copper, 22½lb quick lime, 220 gallons of water. The sulphate of copper should be dissolved by suspending it in a coarse cloth or basket in water contained in a wooden vessel. Hot water dissolves the sulphate more quickly, but in that case it must be allowed to be quite cold before being utilized. The quick-lime should be slaked in a separate wooden tank or tub, and then stirred into a fine gruel with water gradually added. This should then be passed through a sieve into the solution of copper, the mixture being well stirred the while, and the balance of water added to the total quantity mentioned. With this the bushes should be thoroughly syringed.

Lime, Salt and Sulphur.

817. In the treatment of fungi a solution of lime, common salt and sulphur has also been found useful, in the proportion of, say, 8lb lime, 3lb salt, and 4lb sulphur, for every 12 gallons of water. Mix one-fourth of the water, one-fourth of the lime, and all the sulphur, boil for an hour and half; the salt with the rest of lime to be slaked with hot water, then added to the above, boil again for half an hour longer. Add the remainder of the water, and use when cold.

Advisable to Treat in Early Stage

I have suggested the above treatment more because of the urgency of the case, than from any knowledge of the probable result. Grey-blight is a malady that every effort should be made to stamp out. Like most other blights it can be treated when present to a small

extent, but a very different state of affairs may be experienced when once allowed to be fully and freely established.

BLISTER LIGHT.

101. (a) Exobasidium vexans, *Massee*, sp. nov.*

BLISTER BLIGHT, WHITE-BLISTER.

BLISTER BLIGHT. *Conf. with paras. 89, 49.*

References.—*Peal, Journ. Agri.-Hort. Soc. Ind., Vol. I., Proc., 17th June 1868, xliv; IV. n.s., 1873, p. 126; Baildon, Tea in Assam, p. 45.*

(Reg. No. 100: tube Nos. 85, 108, 155, 208, 210, 257, 262 and 296: botanical specimens Nos. 10421, 11142 and 11959.)

818. HISTORY.—The earliest mention of this blight occurs in the *Journal of the Agri.-Horticultural Society of India for 1868*, where it will be seen the late Mr. S. E. Peal furnished samples, and expressed the opinion that it was most probably caused by a fungus. He there stated that he had first known it ten years before, so that, if anything, this may be said to be one of the earliest, as it is to this day, one of the least understood maladies of the tea plant.

Mistaken Identification.

The Secretary, Agri.-Horticultural Society, in submitting Mr. Peal's samples remarked that, "the disease appeared identical with that which caused so much damage last year in certain gardens in Cachar, but, unlike Mr. Peal's experience, it attacked the China plants principally." At the period in question it was mosquito that "caused so much damage in Cachar." Mr. Baildon is the only author of a book on tea (published 1877) who makes mention of blister-blight. His remarks may be here quoted in full:—"I think this is worse than mosquito blight. I do not know whether it has been really ascertained what causes "Blister Blight." A leaf gets a small speck upon it at first, which, as it enlarges, assumes the appearance of a blister, and ruins the leaf entirely. An old belief was, that when a drop of rain or dew remained on a leaf, the sun coming out acted as a magnifying glass upon it, and burnt a hole. Others believed the blight to be caused by a bug. I think this most probable." The sun theory of blister is constantly brought

Worse than Mosquito.

Sun Theory.

* While engaged on the preparation of this report I furnished the Director of the Royal Gardens, Kew, (July 21st, 1897) with a complete set of my collections of fungi, found on the tea plant in Assam. In the report which I have had the pleasure to receive from Mr. W. T. Thiselton Dyer, (dated November, 17th), Mr. George Massee furnishes his scientific determinations of two species, *viz.* Blister Blight and Thread Blight (*for the latter see page 433*). The present report being now in final page proof I am only able to insert the scientific names furnished and this brief acknowledgment. Mr. Massee's detailed account of these fungi and of Pestalozzia Guepini, which I understand will appear very shortly in the Kew Bulletin, will be awaited with much interest.

EXOBASIDIUM VEXANS.

up to account, not only for the present disease, but for the minute blisterings of the mites. I have never seen a case of sun blistering, and suspect there may be some mistake. If it does occur, excessive evaporation, and not the magnifying glass theory, would have to be accepted as the explanation. (*Conf. with para. 119.*)

Distribution.

819. By way of concluding this review of the facts that have a bearing on the history and distribution of this malady, I would here add that I have failed to find evidence that it has ever visited Cachar, Darjeeling, the Duars, in fact any other part of the tea area than Assam. And even in Assam it is very erratic. It is most prevalent in Sibsagar, is perhaps unknown in Dibrugarh, occurs in North Lakhimpur, but does not appear to have reached Biswanath, Tezpur nor Nowgong.

820. DESCRIPTION.—The following is Mr. Peal's account of this blight. I make no apology for giving it in full since it practically tells all that we know to the present day, and shows that the chief peculiarities of the blight have not been modified in any essential, during the past forty years or so :—

So Common as to be Called an Epidemic.

"I take the liberty of enclosing some leaves of tea that have been attacked by a kind of white-blister. This disease is so common about here just now, that it might be called an epidemic. It attacks young leaf, and is injurious, inasmuch as it stops the bush to a great extent in giving leaf. I have noticed it, sparingly, for some years, and have not been able to ascertain the cause, but I apprehend it is a fungus 'smut or rust,' and not caused by any insect.

Attacks Young Leaf.

Attacks also the Green Stem.

"It is chiefly confined to the leaves, but it is also seen occasionally on the green part of a stem, or the green husk of the seed. When fresh, it presents the appearance of a pale green spot (usually pitted) on the upper surface of the leaf, and on the lower surface is seen as a raised white blister-like spot with a floury or mealy texture, usually circular. The diseased portion eventually turns a brownish colour, and the leaf, wholly or in part, dies.

Pale Green Spot.

Below a White Blister.

"So far as it seems peculiar to tea, I have searched for it in vain on other plants, as it seems to attack it under all circumstances alike, equally so in the open as under shade, in jungle or in clear and highly-cultivated patches : this, at least, is my experience so far; varieties of Tea, including the 'China,' seem to suffer less than those more nearly allied to Assam. I have reason to believe that this disease shows chiefly after long heavy rain. I had

Assam Indigenous Jats.

heard so before, and this year would seem to confirm the supposition, the rainfall during April having been very heavy. A patch of Tea near here, of 20 acres or more, has been so generally attacked by *this disease, that I have ceased to pluck it, and the* garden *in* places presents quite a withered appearance. Other gardens around are also suffering, the disease being, if anything, on the increase. I have heard that, about ten years ago, the tea suffered severely from this same blight, but that the following season it all but disappeared. It will certainly have a marked effect on all the estimates of 'crop,' as it seems to check leaf coming out." **BLISTER BLIGHT.** **Plucking Discontinued.**

"The Secretary remarked that, "the disease appeared identical with that which caused so much damage last year in certain gardens in Cachar; but, unlike Mr. Peal's experience, it attacked the China plants principally, while the Hybrid suffered but partially, and the indigenous was scarcely affected at all."

821. By way of comparison with Mr. Peal's description it may be useful, if I record here a description of the blight as met with by me. It first appears as a minute pale brown or pinkish spot on the upper surface of the leaf. This enlarges in size, mostly in a perfectly circular manner, gradually becomes depressed into a pit about the size to admit the tip of the little finger, is smooth, polished and glistening, as if coated with honey-dew. On the under side of the leaf there is a corresponding swelling which is pure white, woolly and soft, but quite dry. **Appears First as a Minute Spot.** **Becomes Depressed and Glistening Above. Swollen, White and Woolly Below.**

822. The appearance of the structure recalls forcibly many of the larger blister-galls, except that these do not form pits above, corresponding to the wart-like swellings below. But blister-blight is in no way of insect origin, but, on the contrary, is caused by a truly parasitic fungus that belongs to a group of forms sometimes spoken of as the blister fungi. A tea planter of considerable experience, in Dibrugarh, assured me that he knew blister-blight perfectly, though there was none of it at the date of my visit that he could show. He further said that, as a remedial measure, he sent out the coolies to collect all affected parts (leaves, buds, etc.), and that on being brought into the factory these were burned. The pluckings were placed in baskets and covered over to prevent the escape of the very minute insects which, he assured me, caused the blight. I presume that some such experience may have led to the association of **Assured by a Planter was Caused by an Insect.**

EXOBASIDIUM VEXANS.

the term blister-blight as synonymous with green-fly. But to resume the description of the blight: as it advances, numerous blisters appear on the same leaf and even coalesce into large patches. They also occur on the young shoots, and cause large hypertrophies of the axis. In time the blisters change colour, become brown, and ultimately black. The shoots next wither, and the entire plot of tea may then look as if a blast from a furnace had passed over it and killed every shoot and leaf.

Large Patches Formed by Coalescence. They Change Colour, Become Brown then Black.

823. This is truly one of the most alarming of maladies and, but for two considerations, would render tea planting impossible:—

Lasts for two Months.

1st.—It lasts for at most two or three months, then disappears, and the bushes rapidly recover.

Is Erratic in its Recurrence.

2nd.—It is most erratic in its occurrence and recurrence; that is to say, it may be very severe for a year or two, and disappear suddenly and unexpectedly for the next half dozen seasons, only to come back again when least expected. But it invariably manifests one peculiarity, which as yet it has shown little tendency to alter, *viz.*, a remarkable preference for unpruned Assam indigenous tea. In fact, it may be said that if a garden possesses no Assam tea flushing in February and March, it will escape this blight, unless it chances to be in close proximity to a garden where these conditions exist, in which case, as the season advances, it may become contaminated. Once introduced, the malady extends to the later flushing teas, but appears never to attack China, nor low class hybrid bushes.

Appears First on Unpruned Tea.

Spreads Rapidly.

824. Depredations.—As just stated, this very remarkable blight attacks chiefly the higher *jat* indigenous teas, and is confined to unpruned tea in the first instance. As remarked by Mr. Peal, it seems, however, highly probable that certain climatic conditions are essential to its becoming established on tea. This is no uncommon circumstance in the development of fungi. The germs exist year after year, but to so limited an extent as to escape observation, and only assume gigantic proportions on the recurrence of favourable conditions. It is essentially a disease of Spring, and lasts for about two months from the date of its first appearance, although it would seem to occasionally recur at other seasons, and in some few instances has been

Climatic Influence.

BLISTER BLIGHT.

Appears to Originate in Proximity to Jungle. ***Conf. with paras. 896, 883.***

Getting More Severe.

Shade Favours the Blights.

Radiation from Point of Origin.

reported to exist in a mild form throughout the year. In a garden visited by me on the 7th April, there was a plot of high class tea that had been collar pruned in December 1893. It sprouted in February 1894, was not pruned the following Autumn, but was once or twice plucked in the Spring of 1895. Blister-blight, however, appeared, and, at the date of my visit, every leaf and shoot was literally covered with the disease. It appeared on the 20th March, near the jungle and in a shady part of the plot. It would thus seem that young fresh shoots, on unpruned tea in early Spring, are peculiarly liable to this disease. But in the garden to which I allude it had extended from the unpruned plot, very nearly all over the estate, attacking all the leaves of the Assam *jats* as they appeared, but avoided arbitrarily the China and hybrid plants. The manager was of opinion that blister-blight was each year getting more severe—certainly nothing could have been more disastrous than the state of affairs seen by me. Within a radius of perhaps 20 miles or so, every alternate garden was, at the time I speak of, found to have blister-blight more or less severely and, in each instance, it had appeared upon unpruned tea, near the jungles or under the shade of avenue trees. The extracts from my diary, which will be found below, afford in several directions suggestive observations. But it may be here remarked that the point of origin and radius of distribution around each centre was most significant. Extending away from the unpruned plot of each garden, the plants were found black, where the disease had first appeared, white with large blisters in the intermediate zone, and sprinkled here and there with glistening spots, on the limits of distribution. There could be no room for doubt as to the point of origin, having been on the early flushing unpruned or lightly pruned tea, and the distribution or rather radiation toward the later flushing bushes.

Dis-appearance.

In the following season (1896) a mild attack appeared, and in 1897, when I wrote to a dozen gardens or so, asking for fresh material to enable me to examine the fungus in connection with this report, I got the same answer all over the province that the disease had entirely disappeared. But I am led to understand that this is by no means an unusual circumstance, and that it is a well-known fact that blister-blight suddenly appears, and as suddenly disappears, in a very unaccountable manner.

Vegetable Parasites of the Tea Plant.

ÉXOBASIDIUM VEXANS.

Plucking.

825. REMEDY.—Most planters have assured me that, if the bushes are promptly and severely plucked, on the blight appearing, it can be got under hand and checked. Mr. Alexander, whose opinions will be found below, in the passages extracted from my diary, found lime an effectual cure. There would seem every reason to suppose that this fungus could be materially checked, if not eradicated, with the fungicide treatment recommended for grey-blight. Although the active portion of the blight appears on the under side of the leaves, there would be little difficulty in reaching the patches, owing to the affected leaves becoming contored with the blisters so as to bring the under surface into full view. I would, therefore, recommend that, on the first appearance of this blight, the bushes should be freely syringed, and for this purpose it would be desirable to be fully prepared, in all gardens where unpruned tea exists. A stock both of the fungicide fluid, ready for use, and a liberal provision of syringes should be at hand. It is probable that moping the affected flushing shoots with a large brush made of flax or *sunn*-hemp, might be found fully as expeditious as syringing. If not, it seems probable that syringes on the native pattern might be made of bamboo at a mere nominal cost. There is no doubt that in the treatment of all pests and blights by insecticide and fungicide fluids success depends upon promptitude. If allowed to invade a large area of the garden, such treatment, in my opinion, becomes quite impracticable.

Lime.

Fungicides. *Conf. with para. 411.*

Promptitude Essential.

Diary Notes on Blister Blight.

Sibsagar District.

826. On the 6th April, I had a conversation with Mr. B., of ———, in the Sibsagar District, on the subject of blister blight. As it may be found of interest, it is given in the form of question and answer:—

1. On what class of soils does the blister-blight appear? Damp low-lying soil, adjoining the jungle.

2. When does it appear? March.

3. When disappear? It varies, but usually it exists only two months, though in some cases it may be seen throughout the year.

4. Have you any idea of its causation? No. It appears on strong and weak bushes alike.

5. Does it run a regular course on each plant? Yes. It appears as glistening pale-coloured depressions on the upper surface of the leaf, which become white and woolly-looking below. These invade the young leaves and twigs. After the plant has been thus attacked, the diseased portions wither and turn black, and the blight disappears from the bush, but leaves it as if it had been burned and the flushing shoots charred.

6. Do the bushes go through these stages simultaneously? No, one after the other as it extends. For example, bushes in the black stage may

Fungi on the Leaves—Blister Blight.

now be seen on the circumference of the garden, approaching the forest' while pretty nearly all over the garden others with blister blotches may be found, the further from the original source the fewer in number. **BLISTER BLIGHT.**

7. Do you know any cure? No.

8. Do the bushes recover? Yes, and then appear as if they had been severely plucked.

On the 7th April, I had a conversation with Mr. A., of ———, on the subject of blister-blight. He informed me that, in his opinion, the blight would not occur were all collar pruned plants again pruned in the ordinary way. He remarked that the disease first appears on the portions of the garden not pruned. For example, a plot of land, 12 acres, was collar pruned in November-December 1893. The shoots appeared February 1894, and were left alone till March 1895, when it was plucked twice. The plot was thus in leaf right on from that date, whereas the rest of the garden around had been pruned until only the old leaves were left on the bushes. In other words, the 12 acres were flushing before the other portions showed any signs of activity.

Appeared on Unpruned Tea.

The blight appeared about the 20th March, after the plot had been once plucked, and was first noticed near the jungle in shady positions. It then spread over the rest of the unpruned, and ultimately the flushings of the pruned tea. It is now met with all over the garden, more prevalent near shade as, for example, alongside of the avenues.

Appeared near the Jungle and under Shade.

It would thus appear a fair inference that the unpruned bushes having young fresh vigorous leaves in March are in a fit state to be attacked by the blight. The rest of the garden having at that season only old hard leaves afforded no opportunity for the pest. This idea is confirmed by the fact that even now only the young vigorous leaves are attacked, not the old hard ones.

Attacks Young Vigorous Shoots.

It is certainly very significant that the blight, as seen by me, was in a radius around the two plots of unpruned tea, and diminished on advancing away from these centres until, at a certain distance, it was hardly to be seen anywhere.

Mr. A. is of opinion that blister-blight is getting more serious every year. The bushes are for the time being destroyed. When they turn black the disease stops, it has run its course, and in two months' time the plants recover. It disappears, say, in May, and does not return till next spring, but during these months it may stop the yield entirely of the portion or portions affected.

Bushes for Time being are Destroyed.

Speaking of blister-blight Mr. S. E. Peal (9th April 1895), said that he had never seen it except near shade and in the vicinity of forest. He first observed it at Sonari and Jaipur near forest and always under shade.

Appears near the Jungle and always Under Shade.

At a garden in Sibsagar (visited April 11th), I found blister-blight here and there.

On April 11th, visited a garden that had a plot of tea that had only been trimmed last autumn, not pruned like the rest of the estate, and which accordingly sprang into early flush; blister-blight had appeared on the unpruned bushes very badly.

During the inspection of a garden on the way to Amguri (April 18th and 19th), the Superintendent (Mr. G.) informed me that blister-blight

Vegetable Parasites of the Tea Plant.

EXOBASIDIUM VEXANS.

first appeared on unpruned tea about the first week in March. It has now spread to all kinds of tea, and is practically all over the estate. This is a good garden with a rich red-clay soil: plants very healthy and large except that mosquito and blister-blight are very bad. It is an open and exposed with little or no shade.

Jorhat.

April 24th, visited a garden in Jorhat Division, blister-blight rare.

At a garden visited by me on the 25th April in the Jorhat Division, I found no blister-blight.

At Jorhat on the 26th April, blister-blight was only once or twice seen.

At Badulipar (May 2nd), I found no blister-blight though unpruned tea existed.

Dibrugarh.

Sixty Maunds of Affected Leaves Collected Daily.

At Dibrugarh on the 15th June, Mr. M. informed me that blister-blight was caused by an insect. He holds that the pustule-like white masses on the back are galls containing eggs. He has sometimes collected as much as 60 maunds a day of the infected leaves. The women used to throw these into their collecting baskets, that were carefully covered over with a cloth. When brought to the factory to be destroyed, he had seen very mute insects, of a grey coloured and ⅛th inch in size, rise in thousands from the baskets. He holds that the infected bushes should be plucked as hard as possible and the pluckings burned.

Plucking Recommended.

He also remarked that the galls extend from the leaves to the twigs in gradually expanding patches until the entire young shoots are invaded and killed. I pointed out that galls were, as he stated, caused by eggs being deposited by an insect, and that, unless the insect returned and deposited more eggs, the galls could hardly, as he affirmed, extend from one part to another, although they might swell in size.

He informed me that he had seen patches of the garden with every twig black, killed back to last prunings. This terrible malady, he remarked, is checked, if not extirpated, if the leaves are persistently plucked, and the pluckings burned. He is certain that throwing the cuttings into the jungle is dangerous, because, as he explained, the insects escape and fly to the tea to infect other bushes. Mr. M. was unable, however, to show me a leaf with the blister-blight on it, so that I was not able to determine whether or not his so-called blister-blight was the pest that I had studied in Sibsagar under that name. It has disappeared now (June 18th) from all the gardens of Sibsagar and Dibrugarh Districts. It appears, as a rule, about March, and by June it disappears. But my experience of it differs greatly from that of Mr. M. It attacks the twigs doubtless, but its expansion from one spot to another and the enlargement of the spots is inexplicable as it seems to me on the theory of its being a gall as usually accepted. Had winged insects been found in association, I should have seen them, or at least the dozens of other planters with whom I had conversed would have seen them. I repeatedly enquired if any insects had been observed hovering over the bushes, but got the answer invariably that no insect had been seen. I was thus prepared to be incredulous of Mr. M.'s observations. In consequence I informed Mr. M. that his blister-blight and that found in Sibsagar, and of which I had seen many hundreds of acres badly infected were two entirely different things. But I have no sort of opinion what the Dibrugarh blister-blight could be unless

Blister Blight Reported to be Caused by an Insect.

Fungi on the Leaves—or White-blister.

Mr. M. made the mistake that I find in the Museum Notes regarding blister-blight as another name for green-fly. **BLISTER BLIGHT.**

At Panitola, visited on the 26th June, no blister-blight was seen. I mentioned the circumstance recorded on the previous day, and said I was particularly anxious to see the blister-blight of this district. I was shown grey-blight and told that generally bore the name of blister-blight. **Panitola.**

On the 27th June at a garden in the Dibrugarh District, I was told that blister-blight had been bad on unpruned tea, but I saw none as it was over.

During a very interesting conversation with Mr. Lindsay Alexander at Patalipam (North Lakhimpur), July 6th, 1895, I learned that, in his opinion, blister-blight usually appears on unpruned or very lightly pruned tea. It generally is first seen about the beginning of April, reaches its height in three weeks and disappears within six. The withered leaves with black patches, caused by the blister, if not removed, remain on the bush till August, and the shoots that had been invaded may be seen even longer than that, as black dried up twigs. **Patalipam.**

Mr. Alexander informed me that he first saw the disease in 1875, in the seed gardens at Bazaloni (one of the finest of indigenous Assam teas), but it never spread, nor did serious damage for many years. He further remarked that in Patalipam it may have existed in 1890 or before that date, but on his taking charge it appeared in April of 1891 and on tea near the N.-E. jungles. Tea considerably to N.-W. and W. has not as yet been attacked. It spread to S. and S.-W., proceeding W. in the first instance, but it never crossed to the Western jungles. The garden extends N. and S., the river being S. The winds during day blow from the river up the garden, at night the reverse. The ice-cold water of the river, Mr. Alexander thought, might exercise a local influence in checking the spread of the disease, consequently, if diffused by the wind, it most probably was distributed at night.

In December 1894 (and this was the first time he had seen it so late in the year), it appeared near the river, right on the bank, and affected only two or three plants. But in the following spring it re-appeared also near the river to the westward and spread N. W. In addition to this it appeared spontaneously in other spots but always near the jungles. **Appeared in December.**

Mr. Alexander regards blister as the most deadly of all blights, for the time it lasts, since it kills everything. Lime water had been found of value. It blackens the white under patch of the pustules, and appears to kill the disease. But if taken in time, plucking the affected parts is of great value in checking diffusion. At Dirpai, plucking had been perfectly effectual, every leaf and twig which showed blister was instantly plucked off during April, with the result that the disease disappeared for good from that garden. **Most Deadly of all Blights.**

At first Mr. Lindsay Alexander was disposed to think blister came from a very common Ipomæa that shows large yellow blotches very much like blister. He had arrived at the opinion, however, that this was not the case. He procured a few leaves for me and I confirmed his conclusion. The Ipomæa was attacked by an unmistakable fungus, absolutely unconnected with blister. I mention this circumstance, however, since several planters have sent me leaves of that very plant, showing that the mistake was one that might be readily enough made. Mr. Alexander failed to discover the disease in the jungles, and two or three days were spent by me in the same fruitless search. The fact of its appearing late in the year in **Plucking Useful.**

Vegetable Parasites of the Tea Plant.

BROWN BLIGHTS.

a spot where, in the following spring, it reappeared with great severity is most instructive, and shows that the disease is one that cannot be trifled with.

Gopesadarhu. At Gopesadarhu, visited on the 12th July, blister-blight was unknown.

Salonah. At Salonah, visited 17th July, Mr. Henderson informed me that blister-blight is not known in that district.

Tezpur. Tezpur, the planters of this district are unfamiliar with blister-blight.

Brown Blights on the Leaves.

Brown Spots on the Leaves. Sudden Developments. Scientific Names.

827. Under the above name I collected three or four species of widely different epiphyllous fungi that all agree in one point, namely, that they cause portions of the leaf to turn brown. These brown patches ultimately decompose into perforations, or large portions of the leaf crumble away or subsequently become mouldy and rotten from being attacked by saprophytic fungi. Though one or two of these fungi are fairly prevalent and even cause considerable injury to tea, they can hardly be classed as definite blights. I should not at all events, in the imperfect state of my information have alluded to them, had it not been for two fairly important considerations:—It seemed desirable that I should in the *first* place distinguish these from grey-blight and blister-blight. In the *second* place, the history of parasitic fungi is replete with instances of certain forms having remained in the position of curiosities for an indefinite time, and to have then suddenly assumed alarming proportions and become dangerous blights. It is as well, therefore, that whether, at present comparatively harmless and only rarely met with, or destructive and prevalent, every parasitic fungus, found on tea, should be made known and as far as possible eradicated. Since, however, I am unable to assign to all the blights of this group, their scientific names, I shall describe them in general or popular terms.

102. (c) BROWN SPOTS WITH A PALE-COLOURED MEMBRANEOUS EXPANDING BORDER.

(Botanical Specimen Register No. 11909.)

Conf. with para. 88.

828. This blight is met with here and there all over the valley of Assam, but curiously enough is more especially prevalent on the plants in the seed garden than elsewhere. In the condition I wish here to specialise there is no pitting of the upper surface, no soft hairy swel-

ling below, as in blister-blight. The upper surface does not become greyish-white, through the separation of the epidermis, as in grey-blight. The spots are formed, as a rule, not more than a quarter of an inch in diameter, but occasionally twice that size. These are dark coloured, dry, and never enlarged in size. They are from the earliest stage surrounded by a pale border or rim that at once fixes their shape and size. The most striking feature of this malady is that the pale borders widen and those of adjacent spots may even coalesce, without there being any union of the central brown spots themselves. The advancing and expanding rim is in fact the seat of the active disease. In time these pale bands turn straw coloured, become dried up and almost membraneous. On reaching the margin of the leaf, they cause a constriction, so that the affected portion turns over and shrivels up. The original central spots now appear like islands within the expansion of chestnut-coloured and membraneous dead leaf tissue. Each of the original central spots will be seen, especially when examined on the under side, to be surrounded by a very dark, almost black zone, that demarks it from the original pale-coloured border. In time the central spots fall out, when the leaf appears perforated (should the expanding rims of several not have united) as if a charge of large shot had been fired into the bush and riddled all its leaves.

BROWN SPOTS WITH PALE RIM.

Description.

Expanding Pale Coloured Border.

Leaves Perforated as if by Shot.

829. At one seed garden, visited by me, I found a large percentage of the fruit-bearing bushes covered with this blight. I asked the superintendent if he had tried to check the spread of the malady for, to say the least of it, such wholesale destruction of the leaves must weaken the seed. I also enquired whether he had ever taken any steps to ascertain whether the fungus was communicable through the seed. I was examining the fruits, many of which showed on the external rind similar destruction to that on the leaf, when the Native overseer informed me the disease could also be seen on the seed itself. I opened up one or two fruits and found, just as the overseer stated, that the seed leaves (cotyledons) were distinctly invaded by very similar fungal spots. Whether the embryos are simply thereby killed, and the seeds rejected as dead, during the selection that takes place before consignments are sold, or they carry the disease to the nursery and to the tea garden, I was not able to ascertain. But the suggestion here made seems to call for investigation. I

Must Weaken the Seed.

Embryos seen to bear Fungal Discolourations

BROWN SPOTS WITH PALE RIM.

undertook to germinate some of the seed, taken from a particularly badly infected tree, if the superintendent would send me some when ripe. Shortly after, I was told a supply had been despatched for me, but that unfortunately the coolie on making for the railway station had been robbed of his parcel. I was thus deprived of the opportunity of investigating a point which I venture to think of considerable interest. But I may add that, during my further explorations, I carefully examined the plants said to have been raised from seed derived from the seed-garden in question, and failed to establish any relation between the source of seed supply and prevalence of this fungus.

Disease Communicated by the Seed.

103. (c) Marginal Corrosion.

(Botanical Specimen No 11937.)

Margin of Leaf Eaten Away.

830. Another fungous disease, in some respects like the last, is fortunately not common, but does considerable damage where it occurs. The texture of the leaf, generally on one side but may be on both sides of the midrib, shows pale discolorations. These enlarge until considerable portions of the leaf are invaded and become pale coloured. They then gradually change into brown and a fungus appears on the margin, and eats inwards until the leaf may be reduced to a midrib and few fragments of the blade. As the decomposition advances, a pale line of demarcation is moved forward and the texture behind crumbles away.

I met with this in one or two gardens only, of the Dibrugarh District. But this malady, as also the last mentioned, may, however, be associated with grey-blight, and are thus not very readily recognized. It is in consequence probable that this blight is more extensively distributed than might at first sight be supposed.

104. (c) Large leaves turned over and attacked by a Fungus near the base.

(Botanical Specimens Nos. 11145, 11323.)

Leaves Folded Over Near the Base.
Conf. with para. 77.

831. Closely allied No. 103, in external appearance, are two other conditions with which the practical man is familiar. In a peculiar form of the indigenous plant, with specially large thick, dark green, hard leaves, a portion of the base of the leaf (on one side of the midrib) turns purple. As this progresses the top portion of the leaf falls over and the discoloured patch gradually changes into brown. Soon thereafter it is invaded by a fungus, but whether saprophytic or parasitic I could not be certain. The part dies in time and becomes decomposed

so that the leaf is eaten away in a manner not unlike the marginal corrosion above described. This occurs all over Assam, but on the *jat* of tea denoted, and no other.

FUNGAL PATCHES in CONCENTRIC ZONES.

105. (c) Marbling of the Leaves.

(Botanical Specimens Nos. 11335 and 11928.)

Variegated Leaves. *Conf. with para. 802.*

832. It is not uncommon to find what might be spoken of as an anæmic condition. All the leaves of a particular bush, or it may be a section of a bush, turn pale green with portions even pure white. At an early stage the margins of such leaves wither, shrivel up and become attacked by saprophytic fungi. This appears to be a constitutional disease, or may be due to the presence of some grub eating the roots or a fungus on the roots. I observed, for example, that the condition indicated prevailed to a very great extent in gardens affected with what the planters know as "Red Rust," though I also found it in instance where I could detect no trace of that alga. However, from the point of view here specially desired to bring out, the margins of such leaves in time become eaten away, in a manner very similar to that which I have described as a fungus that produces a marginal corrosion of the leaf (*No. 103*).

Red Rust.

106. (c) Chestnut Patches built up of Concentric Zones.

(Botanical Specimens Nos. 11338, 11905 and 11935).

Decomposition of Leaf Tissue by Fungal Patches that Expand in Zones.

833. All over Assam, both on the tea and on the leaves of many jungle plants as well, one comes across very frequently examples of a beautiful fungus or of several species of fungi of the kind it is here desired to specialise. This commences by a minute point, which turns to a chestnut colour, the leaf tissue then shrinks in thickness and becomes quite dry. Layer upon layer this widens and absorbs veins, midrib, or any part of the leaf with which it comes in contact. Zone upon zone, each clearly demarcated like the layers of exogynous wood in a transverse section. As the fungal patch enlarges, it seems to abstract moisture from the adjacent tissue, for the leaf contracts, thus causing the perfectly smooth and shining fungal patch to show up very clearly. The leaf is slowly killed and in time falls to the ground, but as only a leaf here and another there, is so invaded, the fungus can hardly be regarded as a blight.

834. But in one garden I came across a slight modification of this condition where the fungus or what appeared to be a similar fungus

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BROWN RINGS.

Similar Condition Assuming the Prevalence of a Blight.

was so prevalent and destructive as to rise to the position of a distinct blight. Between the veins, the tissue became swollen or bullated, with irregularly shaped alternating pale-coloured and dark patches. The plant was in fact richly variegated with many leaves straw coloured, deepening into orange and finally brown. At this stage every leaf bore one or more dark brown fungal patches that widened in circumference by adding zone upon zone as in the condition just mentioned. But only in the advanced stages did these concentrically formed patches show through to the under surface.

Bushes are Defoliated.

835. In the advanced stages of this blight the plants became leafless, and in many respects thus resembled the condition characteristic of grey-blight. **(Pestalozzia Guepini.)** At no stage of this blight, however, were the leaves seen to be grey, nor the invaded portions built up of numerous centres that had coalesced. That is to say, the patches do not originate from a multitude of minute spots, but from a very few points rarely adjacent and only very exceptionally coalescent. Moreover, their formation is restricted to the spaces between the veins which, at first almost straw coloured, gradually deepens until the concentrically formed fungal patches are fully developed.

Superficial Brown Patches with Embracing Rings.

107. (c) Brown Rings one within the other.

(Botanical Specimen No. 11882.)

836. This very remarkable leaf discolouration I only came across on one or two occasions. At Ligri Pukri I found a clump of half a dozen bushes affected with it; again at Hautley a few more; and at Dum Duma it seemed fairly abundant. In all these instances, however, it invariably appeared on Assam indigenous plants. The bushes were stunted, the leaves abnormally broad, and the marginal serrations hard and sharp. The leaves were spotted all over with curious markings of a dark green to brownish shade. These originated with a small circular spot, that showed on both the upper and under sides, as if a drop of gum had hardened on both surfaces simultaneously and formed a rather thickish superficial patch with a thick rim. Then semi-circular bands of discoloured tissue, one within the other, imbricating or uniting into more or less perfect rings, were seen to be arranged around the central patch, each of the embracing and surrounding bands being separated from the other by about an eighth of an inch of pale green leaf tissue. On the surface of the central patch a few black circular

Brown Blights on the Leaves.

apothecia-like bodies were recognised, but these, in all the specimens examined, were but imperfectly formed so that I was unable to discover the spores. THREAD BLIGHT.

To a certain extent the central patches resemble those of grey-blight, but apparently they never unite together, and the embracing circles of discoloured tissue (which in the dried leaf become almost black in colour) are most peculiar. In some respects these striking discolourations recall the species of epiphyllous fungi referred to the genera of **Phyllosticta** or **Depazea**. They can hardly be called diseases though they denote a want of vigour.

108. (c) Black Fungi on the Leaves. BLACK FUNGI. *Conf. with paras. 514, 617.*

837. Under the account "of Red-rust" mention will be found of a black fungus that is often seen on the tea leaves, in association with the orange-red patches of the alga (**Cephaleuros verescens**). It not infrequently happens that in a damp situation, or near the jungles, this fungus is very prevalent, without being accompanied, in any very special manner, with the foliar patches of red-rust. The fungus to which I allude is, however, purely epiphyllous, and further than possibly harbouring other pests does not appear to be injurious. (*Botanical Specimen No. 10424.*)

838. In connection with the account of Scale-insects, mention has also been made of another black fungus found on the tea leaves. A sample of this form having been furnished to the Director of the Royal Botanic Gardens, Kew, it was found to be **Capnodium Footii**, *Berkl.* and *Desmaz.* Mr. Dyer in furnishing the determination, wrote that the species had not previously been recorded as met with in India, but that it was common on the **Camellia,** in cultivation in Europe, and was the species that blackened the lime-trees (**Tilia**), in the latter case appearing in association with the honey-dew aphis. (*Botanical Specimen No. 9060.*) **Associated with Scale-insects or Aphides.** *Conf. with paras. 46(2), 617, 638-9, 801.*

LXXI.—Blights on the Stem.

109. (a) **Stilbum nanum,** *Massee, sp. nov.* (*See foot-note to page 419.*)

Thread Blight also known as Wither Blight. THREAD BLIGHT. *Conf. with paras. 89, 173, 480, 482.*

References.—*Journ. Agri.-Hort. Soc. Ind., Vol. I. (n. s.) Proc., 15th July 1868, p. liii; Vol. VI., Proc., 27th Feb. 1873, p. ix; Proc., 19th March 1874, p. xiii; Jour., VII., pp. 258-262; Vol. X., Proc., 27th March 1896, p. 470; Vol. XI., 26th March 1897, p. 601; Tea Planter's Vade Mecum, 104-105; Bamber, Chem. and Agri. Tea, p. 257; Chris-*

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tison (White Thread Fungus), Home and Colonial Mail, Jan. 1st, 1897; Dr. D. D. Cunningham, Scientific Mem. Med. Officers of the Army of India, Pt. X., pp. 20-22.

(Reg. No. 138; Botanical Specimens Nos. 11147, 11334, 11911, 11931, 11932, 11966, 11968, 11970, and 11988.)

839. HISTORY.—The above references to Indian publications show that this fungal blight has been recurrently brought to attention, as an enemy of tea cultivation, during the past 30 years. The late Rev. M. J. Berkeley* was the first mycologist apparently, to whom samples had been sent for examination, and Dr. D. D. Cunningham, C.I.E., the most recent writer on the subject.† Briefly it may be said that until quite lately no one had seen what might be called the fruit-bearing structures of this fungus. The rhizoid filaments (the threads of the tea planters) are the only parts that have, therefore, been available for examination. In popular language these might be regarded as corresponding to the root and stem of higher plants; and hence in the absence of fructification, the species might be characterised as perpetuated by cuttings. It is well known, however, that many fungi can and do exist indefinitely in that condition, or change their structural peculiarities in the fruiting stage to such an extent as to escape detection of the two forms being parts or states of the same species. Dr. Cunningham, it will be observed from his report, which I have taken the liberty to quote very freely, has suggested, by analogy with a similar blight on **Ficus stipulata,** that the fungus in question may belong to a group that produces SCLEROTIA. That is to say, fungi that form hard tuber-like very minute bodies, composed of reserve material, which on being thrown off by the mycelium (the structure in this species that has given the name thread-blight) remain dormant for a time. On the return of favourable conditions they germinate or sprout and produce temporary fructifications which reproduce the species once more in its rhizoid condition. Fungi that assume the habit briefly indicated, are naturally very obscure, and careful research conducted with fresh material is necessary to discover their various stages, and hence their eradication is often a matter of considerable difficulty.

Fruiting-structures. *Rhizoid Filaments.* *Sclerotia.* *Probable Method of Reproduction.*

840. This fungus was first sent to the Agri.-Horticultural Society from Upper Assam, but it is subsequently mentioned as occurring in Cachar and in the Duars. Dr. Cunningham mentions the fact that the

Found in Assam, Cachar, Darjeeling and Andaman Islands.

* Quarterly Jour. of Microscopical Science (1875), pp. 130—3.
† See foot-note to page 419.

specimens examined by him had been furnished by **Brigade-Surgeon Lieut.-Col. Sir George King, K.C.I.E.,** from Darjeeling, and that **Surgeon-Major D. Prain** had found it on tea in the Andaman Islands. **THREAD BLIGHT.**

841. I assume that the thread-blight seen in the jungles of Assam, is the same form as that found on tea. If so, it occurs on a very large number of widely dissimilar plants, of which may be mentioned—bamboo and **Dillenia indica** (the *utengah* of Assam) as the jungle plants on which it is specially plentiful, and **Eriobotrya japonica** (the Loquat) and **Achras Sapota** (the Sapodilla plum) as the fruit trees on which it very frequently occurs. It is, however, by no means unusual on the Mango and may be recognised at a distance on fruit trees by a clump of withered leaves near the extremities of certain branches. **Other Plants on which it Occurs.**

842. DESCRIPTION.—In the early months of the season, this blight may often be seen on the lower part of the stem. The name thread-blight sufficiently describes it. A soft woolly white thread is seen to adhere to the stem and to develope upwards. It is very lightly attached to the bark. In some few instances I have been able to trace a direct connection with buried prunings, bearing the blight, and fresh invasions of stems. In others the thread seemed simply to emerge from the ground. This latter circumstance might be supposed as corroborating **Dr. Cunningham's** suggestion of SCLEROTIA originating new threads. Usually, however, unless removed, the thread is to be seen mainly upon the branches. Very often it does not occur on the stem, and consequently has no connection with the ground. In that position it may continue from year to year, the portion that may be left after pruning starting the fresh attack on each succeeding year's shoots. On running up the young twigs it forms slight thickenings at the joints from which offshoots go to the leaves. The remainder of the thread at each joint then sweeps round the twig to the position of the next leaf, and so on. Each leaf gets its own portion of the thread by which its destruction is effected. On reaching the leaf, the fungal thread thickens on the petiole, twists round and runs up the midrib where it expands into a soft felted layer that ultimately covers the whole under side of the leaf. I never came across an instance where the felted expansion was on the upper surface of the leaf. In this respect thread blight differs essentially from grey-blight, which occurs exclusively on the upper side of the leaf.

Ascending External White Threads.

Threads Usually Seen on the Branches.

Special Threads Sent off to Each Leaf.

Under Surface of Leaf Felted.

STILBUM NANUM.

exceptionally dense texture of the leaves and the fact that in all the specimens the tissues had more or less completely dried up ere they were subjected to examination—conditions which are specially calculated to render the detection of intrusive mycelial elements a matter of extreme difficulty. In the case of many uredinous blights, in which the presence of very large numbers of patches of fructification unequivocally implies the existence of an abundant and widely diffused mycelium within the substance of the tissues, the demonstration of it is frequently a matter of very great difficulty, even in perfectly fresh specimens, and where the host-tissues are dense and the parasitic elements have been subjected to desiccation, the difficulty is naturally greatly increased."

Similar Fungal Blights.

"As has been already pointed out, the phenomena attending the spread of this disease are closely parallel to those occurring in the case of the sclerotial blights of **Ficus stipulata** and **F. volvulus nummularia.** The principal distinctive feature lies in the definite cord-like arrangement which the mycelium assumes in passing from one nutritive area to another. The distinction, however, is not an absolute one, for, although in the two latter blights the mycelium never forms such definite cords, it does tend to become aggregated in the form of strands in passing from one leaf to another or when spreading out from the edges of an exhausted leaf over neighbouring non-nutritive surfaces such as glass or water. The distinction thus is one of degree and not of kind. In none of the specimens which have yet reached me have there been any traces of true sclerotia either within or on the blighted tissues or in the substance of the mycelial cords, but this may very probably have been owing to the fact that the normal development of the mycelium was arrested by the conditions to which it was subjected after the affected shoots were detached. In certain cases renewed active growth occurred in some of the mycelial cords when subjected to the influence of a moist atmosphere, but in the absence of fresh foliar surfaces as a source of new stores of nutritive material it was soon arrested. The phenomena certainly render it extremely probable that the disease is a sclerotial one, but the question is one which can only be determined in a site in which both parasite and host-plant are at home, but in any such site a little careful observation would be all that would be necessary to decide it."

Observation Necessary

846. DEPREDATIONS.—In one garden visited by me along with the superintendent, both thread-blight and grey-blight were present, often on the same individual bushes. We marched right and left through the garden and made an estimate of the number injured. At the lowest possible figure 50 per cent. showed one or both of these blights. The loss in that garden will have to be expressed in the returns for years to come, unless the suggestion I made has been acted on, namely to collar prune the entire garden and burn the prunings. There is no other remedy. This was certainly, however, an extreme case, but I mention it as showing what may and indeed sometimes does exist. Thread-blight is very prevalent in Assam and must be year after year weakening the plants and lowering the yield, over a large portion of the tea area. It is one of those insidious maladies that are often neglected until almost too late. That bushes may appear to throw it off is entirely a matter of pruning. Should the pruners have gone sufficiently low, to remove all the invaded portions, the disease very possibly may disappear. But if any portion of the thread be left, that will assuredly continue the destruction, and year after year sap the life of the bush. By killing a large number of its branches it will also steadily reduce its yielding capacity.

THREAD BLIGHT. **Grey-blight and Thread-blight Often Associated Together. 50 per cent. Affected.** **Is very Prevalent in Assam.** **Yielding Capacity Lowered.**

847. But the withered leaves, adhering to the bush, are the chief agents of dispersion of the disease. I have repeatedly found tea leaves or jungle leaves, more specially the *utengah* adhering to bushes near a point where a new start had been given to the blight. It would thus seem that the disease is readily transmissible and may be diffused all over the garden if a few bushes are allowed to furnish withered and mycelial-bearing leaves, to be carried by the wind. These leaves, on coming in contact with a fresh plant, at once put out a small filament that unites the diseased structure to the new host. But in passing I would desire to repeat that a similar state of affairs would seem to occur in grey-blight, since under that blight the observation has been made that the diseased leaves become attached to healthy bushes.

Mode of Communication.

848. REMEDY.—The following passage completes **Dr. D. D. Cunningham's** account of this blight: "In the absence of precise information in regard to the true nature of the parasite and the exact form and sight of development of the reproductive apparatus, all that can be suggested with a view to the prevention of the disease is that whenever it makes its appearance all infected shoots should, as far as

All Affected Parts should be Removed.

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At a garden in the Dibrugarh District, visited on June 27th, I found no thread-blight.

North Lakhimpur.

At Dum Duma, visited on the 30th June, thread-blight was difficult to see owing to dense dome, but found some bushes affected.

Is Supposed also to Attack the Roots.

At Patalipam (North Lakhimpur), I was told this blight never appeared bad, but, if left on the bushes, it ultimately attacked the roots as well as the branches and killed the plants. It is distinctly communicable and comes from the leaves and twigs of jungle trees blown on to the tea. It may be checked by careful pruning and burning the prunings. It is more serious if communicated to the roots first, as it kills all the young roots. This, Mr. Alexander is of opinion, takes place when prunings with thread-blight are buried.

Favoured by Shade of Sau Tree.

Having crossed the river to the north bank, I was most curious to compare the blights of these gardens with those I had examined on the south bank. At Bordeobam I found thread-blight fairly plentiful. If anything, this blight would seem to be favoured by the shade of the *Sau* trees.

At Gopesadarhu, visited on the 12th July, thread-blight was found occasional.

Mijika Jan.

At Mijika Jan, visited on 13th July, I found thread-blight very common.

Giladharee.

A portion of Giladharee garden, visited on the 14th July, was found to have at least 40 per cent. thread-blight. (*Nos. 11968 to 11970.*)

Koliabar.

On the 16th July thread-blight was found on the lower portions of Koliabar.

Nowgong.

At Salonah, Nowgong District, visited 17th July, I found thread-blight frequent in some places, more especially in confined situations.

Affects of Thread-blight, Grey blight and Red-rust.

At Amluckie, visited 18th July, Mr. J. A. A. Hunter took me to one portion of the estate that might be characterised as a heavy black damp soil, badly requiring to be deep sub-soil drained. The plot of land to which I allude was enclosed by jungle. I found it to have perhaps 20 per cent. of its bushes severely affected with thread-blight, and very often grey-blight as well and even red-rust. I endeavoured to demonstrate the effects of these blights by selecting bushes that manifested their peculiarities. Thread-blight kills off a certain percentage of the two and three year old shoots of the branch or branches on which it occurs, and thus leaves the bush full size, but with perhaps less than half its normal producing shoots. "Red-rust" is somewhat similar in its action in so far that it thins out the flush-bearing timber, but grey-blight is entirely different. It kills the leaves, buds and shoots over a compact portion of the bush, and thus cuts a hole into it or, if very severe, may surround the bush, then work upwards from the circumference, and finally down through the centre, in this case practically or actually killing the entire bush. If only a slight attack, the disease may exist as a fringe round the circumference, or as a patch on one side of the bush. The affected leaves and shoots fall off and the bush apparently recovers. Grey-blight, by being concentrated, is more

Thread-blight Operates Below.

Blights on the Stem.

conspicuous and the dead leaves lie on the top instead of being hid below. It works from the top downwards (or from the outside towards the centre), while thread-blight operates from below upwards, and is thus concealed by the healthy leaves above. In Red-rust all the leaves of the invaded shoot turn pale, some of them even white, and then simultaneously die as the blight advances. But they have simply withered and showed no diseased formations on their surfaces. The seat of the disease is on last year's wood, all above that being gradually starved and killed. **RED-RUST.**

At Solal (visited 18th July), Mr. Moir showed me thread-blight which, he said, was becoming somewhat serious, but he had no other pests of any consequence. I did not personally investigate the garden as I was passing through on my way to Silghat. **Solal.**

At Tezpur on the 20th July, I was taken to see a small plot of land on fairly heavy soil, and surrounded with jungle that had, according to the estimate of the manager, 40 per cent. of the bushes affected with grey-blight and thread-blight. The land was cold and sour, the clods showing a white efflorescence on exposed portions—a sure sign of defective drainage. **Tezpur.**

110. (c) Cephaleuros virescens, *Kunze.*

(Mycoidea parasitica, *Cunning.*, Cephaleuros Mycoidea, *Karsten.*)

THE RED-RUST *of Assam Planters; the* WHITE-BLIGHT *of the early writers.* **RED RUST.** *Conf. with paras. 39, 179.*

References.—*Cunningham, Mycoidea parasitica, in Trans. Linn. Soc., 2nd series, Vol. I., 301-316, tabs. 42, 43; also An Entophytic Alga occurring on the leaves of Limnanthemum indicum, with Notes on a Peculiarly Parasitic Variety of Mycoidea, in the Scientific Memoirs by Medical Officers of the Army of India, Part III., pp. 35, 40, pl. I; and Bark-blight caused by Cephaleuros virescens, Kunze, in Scientific Mems., etc., Part X., pp. 17-20, pl. III.; H. Marshall Ward, Trans. Linn. Soc., (1884) Vol. II, Second Series, Botany pp. 87-115. Plates 18—20; Diseases of Plants by Dr. Karl Freiherr von Tubeuf, transl. by W. G. Smith, 552; Tea Planter's Vade Mecum, 105-106.*

(Reg. No. 139; Botanical Specimens, leaves 10426 : shoots 11989.)

851. HISTORY.—So far as I can discover, this blight first began to attract attention about 1880. It was then known as "White Blight," because of the peculiarity that the leaves of the twigs invaded by it were observed to become variegated, ultimately pure white, as one writer remarked making the bushes resemble "white leprosy." It has similarly received the name of "Red-rust," because of the red-coloured diseased patches seen on the bark of the two or three year old shoots. **White-blight. Red-rust.**

852. DISTRIBUTION.—I have no direct evidence that it occurs as a dangerous tea blight in any other locality than Assam, and even in **Assam.**

CEPHALEUROS VIRESCENS.

Found in Nazira, Nowgong, and Tezpur.

Conf. with Distribution of Mosquito, 556.

Wrong Reported from Dibrugarh.

Assam it is most erratic. I found it in two adjacent gardens in the Nazira Section of Sibsagar; in half a dozen or more gardens within a compact section of Nowgong; and in two or three gardens in Tezpur. The Nazira gardens in question might be spoken of as suffering from defective drainage. The Nowgong hills probably give to the tract of country below them a considerably different climatic condition to what prevails above (namely in Sibsagar and Dibrugarh), but that difference could hardly be accepted as sufficient reason for the prevalence of the blight in Nowgong, nor for its absence from Dibrugarh and practically also from Sibsagar. The report of its occurrence in Dibrugarh is, I believe, due to a garden in that district being under the management of a Company that has its head-quarters in Nowgong. Certain letters, having been issued by the manager during inspection duty in Dibrugarh, gave the reputation of the blight being found in that district. But if excessive rainfall, high humidity and even occasional inundation, be viewed as circumstances likely to favour the appearance and distribution of this blight, it might naturally be looked for in North Lakhimpur and the gardens of the north bank generally, but to the best of my knowledge it nowhere occurs until on descending the valley the latitude of Tezpur and Nowgong is reached. It is thus significant that this blight should be confined to the portion of the Assam Valley indicated. Whether or not it exists still lower down, for example, in Gauhati, Mungledai and Goalpara, I am unable to say, but the restricted nature of its present distribution is certainly highly significant.

Latitude of Nowgong and Tezpur.

It is an Alga.

853. *An Alga not a Fungus.*—But I must hasten to explain that, unlike the majority of the vegetable parasites, indicated in the foregoing pages, this blight is not a fungus but an alga. That is to say, it belongs to the natural order of plants best known by the seaweeds and the fresh water algæ. In general terms, these may be said to differ from the fungi, by their more or less aquatic habit, by their being often highly coloured (frequently green), and by their being only very exceptionally parasitic. The blight with which we are concerned is one of those remarkable exceptions, for it is distinctly parasitic, and to the ordinary observer could hardly help being viewed as a fungus. But it is unfortunate that it has come to bear the name "Red Rust" since the term rust has a very restricted signification,

Is Distinctly Parasitic.

RED-RUST

viz., to one group of fungi, with which this blight hardly bears even a superficial resemblance.

Two Phases in its Life.

Two Phases in its Life.—There is another point that had better be here mentioned—there are two widely different phases in the life of this alga; in one it is found on the leaves of the tea plant, and is comparatively harmless; in the other, it infests the bark and superficial structures of the young shoots, and is in that case a dangerous parasite. In its harmless condition it exists throughout Assam, in the Duars, Darjeeling and Ceylon. It may, and I have little doubt does, exist also in the other tea districts, though I have no knowledge of the fact. It is very common on the wild tea, though I am not aware of the injurious form having been found anywhere except on cultivated plant.

In its Epiphyllous Phase it Occurs Practically Throughout the Tea Districts.

854. *Literature.*—We owe to Brigade-Surgeon-Lieutenant-Colonel D.D. Cunningham, C.I.E., practically all the knowledge we possess on the subject of this very remarkable organism. The first of his scientific papers (mentioned above), deals with the epiphyllous condition, and describes the life history of the alga in every detail. That monograph may be said to bring out three very important facts, (*a*) that it is distinctly a parasitic species, (*b*) that, in what might be spoken of as the starting point of its structural formation, it exists as a minute flattened disk of algal cells which is primarily developed above, but subsequently as a secondary formation, immediately below the epidermis (or cuticle) of the leaf; and (*c*) that the superficial disk may be parasitised by a fungal filament, the combined growth of the alga and fungus giving origin to various forms of LICHENS allied to STRIGULA.

Three Important Facts in its Life History.

It would be beyond the scope of a report on tea planting, more especially on the pests and blights of the tea plant, to enter into detail on the many highly instructive scientific aspects of Dr. Cunningham's investigations, but the three facts mentioned are directly connected with the practical considerations that I wish to elucidate.

The second of Dr. Cunningham's papers deals still with the phase of the alga as found on leaves, and gives details of an instance in which its parasitic character is unequivocal.

Is not Confined to the Tea Plant.

855. In passing, it may be here remarked that one of the many remarkable peculiarities of this organism is the fact that it is by no means confined to the tea plant. It exists throughout the tropical regions of India on an extensive series of widely different plants. In Assam

CEPHALEUROS VIRESCENS.

it might almost be said to occur on any tree or bush, the leaves of which have, like the tea plant, a fairly hard and polished epidermis on the upper surface. Thus, for example, it is common on the Mango, the Letchi, the *Nahor*, the *Satian*, the *Sum*, the *Adakuri*, the Cinnamon, and many others. But it is not likely to be found on the *Sau*, the *Bukhain*, the *Sam*, or other soft-leaved trees common in and around the tea gardens.

Not Found on Soft-leaved Trees.

Deep-seated Phase.

856. The third, and to the tea planters the most important, of Dr. Cunningham's above enumerated papers, deals with the phase in the life of the alga when, instead of living on the leaves, it attacks the bark of one or two year old tea shoots, and becomes a dangerous parasite. In the remarks which follow, I shall take the liberty to reproduce this most valuable contribution, but I shall do so under three separate paragraph headings to which it has in any case practically been referred by the author.

Localities Where Found.

857. Description.—To discover this blight, examine bushes found under the shade of any of the hard-leaved trees named above, or bushes growing near the jungle, or on plots of tea land imperfectly drained or badly ventilated. If the nursery be surrounded by jungle, examine also the seedlings, for you may find these the source from which this blight gets dispersed over the garden. The older leaves of the bushes, in most of the positions mentioned, will almost invariably be found to bear on their upper surfaces numerous orange-red spots that may range from an eighth to half an inch in diameter. Even to the naked eye these spots may be seen to support, especially on the slightly thickened circumference, a crop of minute erect filaments. The centre of the larger spots may also be observed to be dark coloured (sometimes almost black) the tissue of the leaf within the orange-red circle being dead, and in many cases even perforated right through, owing to complete decomposition. These orange-red patches are the epiphyllous phase of this blight.

Orange-red Spots on the Leaves.

Epiphyllous Phase of the Alga.

ASEXUAL REPRODUCTION.

858. *Asexual Reproduction.*—It is preferable to look for the spots mentioned after the monsoons have been fairly established, otherwise they may not be observed to suppport the filaments that give them their characteristic woolly and orange-red appearance. Later on in the season, they may be found to have changed colour and

Blights on the Stem.

become pale green, and in the hot months to have even assumed a grey colour. With the aid of a lens the filaments (examined, say, in June or July) will be found to support on their extremities, very minute rounded heads. These might be called the fruits. By the aid of the microscope they will be found to give origin to spores which eventually produce actively moving zoospores. These swim in the moisture of the leaf surface, or fall from leaf to leaf, more especially in the drip from avenue trees. In time they find a favourable position, become fixed, and each gives origin to a minute flat smooth little disk which, under the lens, will be seen to be very similar to the original orange-coloured patches, only that it does not possess a fringe of filamentous fruit-bearing bodies. This is the primary disk to which I have already alluded. For a time the primary disk remains in that condition, but in due course it may commence vigorous growth or die and disappear. Penetrating the epidermis of the leaf it forms the secondary disk which is placed between the cuticle and sub-epidermal layer of cells. The growth of this new disk raises the cuticle, which in time is perforated. The original disk disappears and the diseased spots of algal structure come, as it were, to be above the surface level of the leaf through the growth of the filaments of the secondary disk.

WHITE BLIGHT. **Round Heads—the Fruits.** **Spores and Zoospores.** **Formation of Disks.** **Primary Disk.** **Secondary Disk.**

859. In other instances the primary disk may be itself parasitised by being attacked by a fungal filament. In consequence an entirely new structure is formed, the combined alga and fungus give origin to grey lichen patches that will be found dispersed all over the leaves upon which orange-red spots are numerous and fairly large in size. Every planter is familiar with the hoary colour of the older leaves of tea trees growing under shade. If such leaves be examined, three very distinct epiphytes will readily attract attention:—

May be Parasitised. **Hoary Leaves.**

(*a*) Orange-red woolly circular patches, raised up above the surface—the alga here described. These will appear to be growing by a constantly widening rim, while dying in the centre of the patch.

The Alga.

(*b*) Irregularly shaped patches of pale grey, more or less completely coalescent and covering the surface of the leaf. Here and there this greyish white coating may be observed to support minute cup-shaped circular bodies either pure black or olive green in colour. These are

Lichens.

CEPHALEUROS VIRESCENS.

Not Found on Soft-leaved Trees.

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Lichens.

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the apothecia or fruiting organs of the lichens, the history of which has already been sufficiently indicated for the purpose of this report.

Fungus.

(*c*) Brownish-black patches with radiating cobweb arms that seem often to cross the grey lichenoid formations. This is a fungus that is found in almost invariable association with the other two organisms. It is very possibly the species found by **Prof. H. Marshall Ward** in Ceylon and described by him in the Linnean Transactions Vol. II. (2nd Ser.) pp. 99-102.

The Lichen and Fungus are Purely Epiphyllous.

860. *Parasitic Action.*—The lichen and the fungus will readily be seen to be purely superficial and to have only a very slight attachment to the leaf. The alga, however, abstracts the sap of the leaf, as will at once be apparent from the circumstance already mentioned, namely, that the space within the actively growing circumference of the algal patch has been killed. It is, therefore, a parasite; but as it invades the old and more or less useless leaves only, it might be regarded as a harmless parasite. Until the destruction has extended sufficiently far to cause an actual perforation, it will rarely be seen to have penetrated the entire thickness of the leaf. Unfortunately, however, **Dr. Cunningham** has shown that, on the leaves of a species of Cinnamomum, this alga no longer exists in the form of what might be designated an absorbent disk (or thallus) placed immediately below the epidermis, and which gradually sucks up the sap of the adjacent tissues, and in time no doubt kills them—thus indirectly parasitic—but that it produces, from its thallus penetrating multicellular filaments, dispersed through the thickness of the leaf, and is thus directly parasitic. In that case the spots are seen on both sides of the leaf, before any disintegration of the central space has been effected. I am not aware of its having been found in this more pronounced parasitic condition on the leaves of the tea plant. There is, however, very little reason why it should not so occur even if it be correct that it has not assumed on tea a directly parasitic form. We know even now far too little about this alga, and if progress in its eradication is to be looked for, greater attention will have to be paid to the comparatively harmless, though exceedingly plentiful epiphyllous phase, in its life cycle.

The Alga is a Parasite.

Penetrating Multicellular Filaments.

Careful Study Still Necessary.

SEXUAL REPRODUCTION.

861. *Sexual Reproduction.*—Before passing away from the epiphyllous condition of the blight, I desire to mention without describing more than very briefly, its sexual reproduction. The production of

zoospores and the formation of the primary disk and subsequently of the sub-epidermal disk, with its crop of filamentous formations that burst through the epidermis and appear on the surface of the leaf, is an asexual reproduction. During the rainy months this is prosecuted with vigour and numerous new patches are formed all over the host plant. But, as if in anticipation of the approach of rainless months and a dry hot atmosphere that would be fatal to most algæ, this species, towards the end of the rains, takes steps to provide for its own safety. It produces, by special organs developed for that purpose on the disk, but underneath the epidermis, a hibernating fecundated or sexual spore (an *Oospore* as it is called) which, stored within the tissue of the old patch, rests until the return of the rainy weather. It then germinates, so to speak, and gives origin to zoospores in every respect similar to those already described, and which in time produce the disk with its asexual capsules. In this way, from fecundated germs or seeds, each year's crop of new epiphyllous patches may originate.

RED-RUST.

Oospores.

THE CORTICAL PHASE OF THE ALGA.

DESTRUCTION of TEA STEMS.

862. *Blanching of the Leaves.*—Turning now to the phase of the alga found on the stem. It has already been said that one of the symptoms of this disease is a blanching of the leaves. This would not appear to be an invariable occurrence, but it is sufficiently frequent to justify a strong suspicion of the presence of the alga when the white marbling already mentioned is met with. It seems probable that other conditions may induce the leaves to turn white, but this alga is undoubtedly the chief and most important cause.

Blanching of the Leaves. *Conf. with para. 839.*

863. When this blight occurs, if last year's shoots be examined, they will be found to be dry and discoloured and to bear on the bark, 2 or 3 inches below the point of origin of the lowest leaves, curiously livid blotches. If these be now examined, they will be found to give indications of supporting some foreign organism, that is in vigorous growth on the periphery of the blotches. It may also be noted that these diseased patches have been deprived of the bark (or rather epidermis) that may be recognised beyond their limitations, on the rest of the shoot. They thus seem sunk as it were within the tissue of the shoot. By holding the diseased twigs up between the eye and the light, it may be noted that, on the circumference of the patches more especially, a large quantity of minute drumstick-shaped orange-red filaments

Will be Discovered on Last Year's Shoots.

Irregularly Shaped Blotches Below the Surface.

Drum Stick-shaped Orange-red Filaments

Vegetable Parasites of the Tea Plant.

CEPHALEUROS VIRESCENS

protrude. These will at once recall the filaments with rounded heads already examined on the epiphyllous patches. **Dr. D. D. Cunningham** has in fact established that the condition here indicated is but a more deeply-seated form of the alga, in which as it continues to grow, the disk (or thallus) that supports these external fructifications is carried deeper and deeper into the tissue of the plant as each superficial layer becomes disintegrated. The bark of the shoots is thus removed by the growth of the alga, and the ascending sap being intercepted, the leaves gradually give indications of decreasing vigour until ultimately the shoot is killed.

Deep-seated Phase.

Disintegration of the Tissue.

Depredations.

864. Depredations.—The action of the alga in bringing about the death of the shoots, on which it occurs, will best be exemplified by now furnishing the passage from **Dr. D. D. Cunningham's** report of his investigations :—

"Specimens of the disease were forwarded to me for examination by **Dr. King**, of the Royal Botanic Garden, Shibpur, to whom they had been originally sent by the agents of a tea garden in which it had been the cause of considerable mischief. They consisted of branches bearing the remains of numerous withered leaves on their twigs. The terminal portions of the twigs where the bark was still young and green did not show any signs of disease, but lower down the surface was either covered by dense felts of the fructifying filaments of **Cephaleuros** or the bark was entirely wanting and the outer surface of the bast exposed to the air. Vertical and longitudinal sections of portions of shoots in various stages of disease unequivocally demonstrated that the destruction of the bark was owing to the disruptive effects produced by intrusive filaments, sheets and solid masses of the vegetative cells of the alga whose fructification clothed the surface in those places where any bark remained adherent. In the earlier stages of the disease the cortex was still of considerable thickness and the algal elements were situated comparatively superficially, spreading out in sheets through the corky strata and breaking up at intervals through it to give origin to erect, fertile filaments on the surface. In more advanced specimens processes could be seen descending through the substance of the host tissues from such superficial layers, and in their turn spreading out at deeper levels to give rise to new horizontally-disposed extensions which broke up the continuity of the surrounding parts, and in still older cases the thickness of the cortex was greatly reduced and algal

Destruction of the Bark.

elements were visible throughout its entire depth right down to the outer limits of the bast. Taking these appearances into account, there can be no difficulty in accounting for the decortication and ultimate death of the affected shoots."

WHITE BLIGHT.

Death of the Shoots.

"It is evident that the disease originates superficially, and is dependent on penetration of the outer layers of the cortex by processes descending from the under surfaces of the normal discoid expansions of **Cephaleuros** which are developed on any suitable surface on which the zoospores may happen to come to rest and germinate. Such processes find all the conditions for luxuriant growth in the constant water-supply and protection from direct exposure to the sun's rays which the cortical tissues provide. They grow freely and spreading out horizontally tend to break up the continuity of the tissues and to cause the desquamation of the layers which lie above them, partly by mere increase in bulk, and partly because they give off numberless emergent fructifying filaments which force their way outwards to the surface. At the same time they in their turn give off descending processes like those from which they originated, which force their way downwards into deeper portions of the cortex and give rise to new horizontal expansions. During periods of sunny weather and relatively low atmospheric humidity, the active growth of the algal elements will naturally be retarded, and, at the same time, the superficial layers of them and the disintegrated cortical tissues will tend to dry up and become detached, whilst the deeper strata of the host-tissues, which retain more continuity, persist and afford protection to the algal elements which they contain. When, on the other hand, conditions of excessive humidity once more prevail, active growth will recur and provide for additional disintegration of the host-tissues, and these processes being recurrently carried on, complete destruction of the cortex will ultimately ensue, and the entophytic elements no longer meeting with a suitable nidus, will also disappear, leaving the bast-tissue completely denuded."

Produced from Zoospores.

Effects of Formation of Fructifying Filaments.

Latent Condition.

Bast Tissue Denuded.

"The mere abnormal drain upon the water-supply of the host incident on the demands of the intrusive algal elements must necessarily tend to interfere with the nutrition of all distally situated parts even fromthe outset, and, with the advance towards complete decortication a purely physical evaporative drain must be established, the ultimate, result of which will be a fatal defect in distal water-supply."

Vegetable Parasites of the Tea Plant.

CEPHALEUROS VIRESCENS.

Occurs in Damp Sites.

865. Conditions Favourable to the Growth of the Alga.—**Dr. Cunningham** continues:—"The disease is described as tending to occur specially in particularly damp sites, which is just what might have been expected from its origin, seeing that excessive damp must, on the one hand, favour the vegetative growth, and on the other, the reproductive diffusion, of the alga. At the same time the destructive effects which it produces are likely to occur most rapidly and conspicuously in sites which are freely exposed to the sun, and therefore at particular times of year subject to considerable desiccation, as this must both facilitate decortication and also render any abnormal drain on the water-supply of the host more injurious. Under the influence of excessive moisture, on the other hand, the extension of the entophyte within the host-tissues will occur rapidly, and fructifying filaments will appear in abundance on the surface of the diseased areas and produce innumerable sporangia, the zopsporic contents of which only require the presence of abundant moisture to become fully developed and endowed with active movement securing their diffusion. They will thus be able to spread from their site of development to other previously unaffected areas, and, on germinating, to serve as sources of infection there. Their diffusion, moreover, under the influence of excessive moisture will tend to be effected not only actively, but passively, as multitudes of them may readily be conveyed in any drop of water running along a continuous surface, or falling from a higher to a lower one. There is unequivocal evidence of this in the excessive prevalence of **Cephaleuros,** which may constantly be found on the leaves of shrubs subject to drip from trees whose leaves are also affected by the alga."

Destruction Most Rapid with Exposure to the Sun.

May be Conveyed in a Drop of Water.

Reproduction

866. **Dr. Cunningham** does not publish any results of his examination of the method of reproduction that prevails in the deep-seated or cortical manifestation of the alga, but, from the concluding sentence in the above passage, it may be assumed to be, in his opinion, brought about by zoospores in the manner which he has so fully exemplified in his admirable account of the species which was published (1880) in the Linnean Society's Transactions. There is, however, a practical consideration of the first magnitude to the tea-planting industry, that would seem still to await solution, *viz.*, the circumstances that induce the zoospores of the epiphyllous condition to become fixed on the bark of the shoots, and to produce there the deep-seated and destruc-

Influences that Induce the Zoospores of Epiphyllous Form to Germinate on the Bark.

tively parasitic condition. That there must be some special conditions, as yet unknown, seems an unavoidable inference from the circumstance that, while no tea garden exists in Assam, in which the epiphyllous condition is not plentiful, the parasitic dangerous phase occurs within a curiously circumscribed area. I make this affirmation after having marched, from garden to garden, over the greater portion of the Assam Valley, and carefully noted the occurrence of the alga on the leaves. So very universally abundant is it that I have no hesitation in saying that it must also occur in the gardens not visited by me. It is certainly more prevalent in gardens with avenue or shade trees (of a particular kind) and in those closely surrounded by jungle, than in the open. But I am prepared to say that, if taken to the middle of a district of many miles of uninterrupted tea, grown on the very best soils, in the absence of all the conditions that would seem to favour the growth of the alga, and with tea of any age or any *jat*, I would have no hesitation in undertaking, within a radius of twenty yards around any spot selected at random, to point out bushes with the epiphyllous condition in abundance. The disease exists in every nursery of seedlings a year old, and from the nursery is carried to the garden, where it continues from year to year on the bushes. But, though I gave the utmost care to this subject, I failed absolutely to find the alga on the bark of the shoots, except in the localities named. Moreover, I had bushes grown in tubs under observation, and was unsuccessful in causing the epiphyllous zoospores to fix on the bark and produce the dangerous form of the blight. And I may also mention another circumstance of some interest, namely, that, while the epiphyllous conditions exist on a large assortment of bushes in the Assam jungles, I never came across an instance of the cortical form, except on the cultivated tea in the localities named.

RED-RUST.

Universality of the Epiphyllous Condition.

The Cortical Form Restricted to a Few Localities.

Never Seen in the Jungle.

867. Remedy.—That the blight described above as met with on the bark is a serious visitation, need hardly be stated. Once it gets established in a garden, its depredations are very alarming. It thins out the bush, branch after branch, and if the pernicious habit of burying the prunings prevails, it is distributed from bush to bush. Fungicides kill the fruiting structures that appear on the surface, but the actively destructive organism being buried within the tissue, is probably unaffected and is likely to continue to grow and to send out time after time countless tufts of its spore-bearing fructifications.

Fungicides.

CEPHALEUROS VIRESCENS.

Mr. Fleet who, during his short residence in Nowgong, started the investigation of this blight, wrote me on the 9th July, "Considerable cold water was at first thrown on my proposal to try fungicides. It is only now, that having proved my point in a small way, materials are being forwarded to allow of my experimenting further." "I have used various strengths of cupric sulphate solutions, also the *Bouillie Bordelaise* fluid. I treated individual plants, selecting bad cases, and consider the result most encouraging. About 36 to 48 hours after application, the external or sporangia-bearing filaments were completely destroyed, and were no longer visible." "The bushes treated on 13th and 18th June have as yet protruded no further filaments."

Pruning.

868. If pruning be resorted to, the result is very nearly as disappointing, since a stage must be reached below which pruning would mean the loss of any return for the season. Bushes must be allowed to carry the one and two year old wood on which the flushings are borne, and a certain percentage of the wood in that condition, within the area of this blight, will be at once invaded, and the process of destruction progresses apace with all efforts towards the eradication of the blight. In one garden, where this blight has assumed the position of being by far the most dangerous enemy of tea, cutting down shade trees, thorough drainage, and chemical manuring, have been carefully and systematically pursued. And along with these improvements by pruning out all affected parts, the blight has been to a certain extent kept under control, but it has by no means been eradicated.

869. From the foregoing remarks it may be gathered that I do not consider we are in a position to prescribe a fixed and satisfactory method of treatment. But it will be useful if I furnish here the concluding paragraph from Dr. Cunningham's recent and most valuable report:—

Prevention.

"In dealing with a blight of this kind, the great thing must necessarily be to prevent it establishing itself in sites presenting specially favourable conditions for the development of the alga. Cephaleuros occurs abundantly on most diverse hosts in tropical regions, but, as a rule, confines itself almost solely to leaves and produces mere localised mischief in these. The affection of the leaves is, generally speaking, of no practical importance, but it may serve as a source of serious mischief where local conditions are such as to favour the excessive growth and multiplication of the algal elements

The Manifestation on the Leaves Dangerous, as a Source of Contamination of the Stem.

and their invasion of axial structures in which their presence may give rise to interference with the general water-supply of the host-tissues. The presence of the alga in and on leaves is readily recognisable from the conspicuous orange, lichenoid patches which the superficial discs and tufts of fructifying filaments form on the foliar surfaces, and the diffusion of the disease is a gradual process, and one which can never occur over wide areas with the rapidity with which that of many blights caused by the presence of parasitic fungi is effected. There can, therefore, be little difficulty in successfully contending with it at the outset, and by the careful removal and destruction of all conspicuously affected leaves when it first makes its appearance, and by avoiding planting in sites exposed to the drip from affected trees, any excessive extension of it, even within otherwise specially favourable localities, might be effectually prevented. Where this has been neglected, however, and it has been thus allowed to establish itself thoroughly and to invade large areas of bark, more drastic measures will be necessary in the form of free pruning or even total removal of entire shrubs and careful destruction of all the diseased tissues. The relatively slow growth and the limited means of diffusion of the alga are such that it can only be as the result of the neglect of such simple preventive measures that the disease can ever become of any serious importance in any locality, but, given the neglect, it may be the cause of very considerable mischief."

WHITE BLIGHT.

Diffusion a Gradual Process.

Removal of all Conspicuously Affected Leaves.

Avoidance of Drip.

Destruction of all Diseased Parts.

Given Neglect it may become a Cause of Considerable Mischief.

870. It will thus be seen that **Dr. Cunningham** gives the planters the assurance that "the diffusion of the disease is a gradual process, and one which can never occur with the rapidity with which that of many blights caused by the presence of parasitic fungi is effected." But observe that view is qualified by "the great thing must necessarily be to prevent it establishing itself in sites presenting specially favourable conditions"; also by "the careful removal and destruction of all conspicuously affected leaves when it first makes its appearance." Now, I believe I am correct when I say that, in no garden in Assam are the leaves affected with this blight collected and destroyed, not even in the districts liable to the form that invades the stem. It is not now a question of preventing the alga from becoming established, but one of its eradication. I repeat it occurs in every garden in Assam, and very possibly upon 50 per cent. of all

Leaves never Collected and Destroyed.

Important Lessons.

Vegetable Parasites of the Tea Plant.

CEPHALEUROS VIRESCENS.

the bushes in the valley. Under these circumstances the points of pressing urgency would seem to be as follows :—

(*a*) Has it been proved that the foliar condition can and will originate that on the stem ?

(*b*) What are the conditions that favour or retard the transmission of the blight from the comparatively harmless to the positively dangerous condition ?

871. Were these questions answered, we would be in a position to lay down definite rules to ward off a possible invasion of the entire tea area with this, one of the most destructive and most dangerous of all tea pests and blights. It was these considerations that led me a year ago to write, "Should, by any unforeseen circumstance, the germs that exist in every garden change from the one condition to the other, "Red-rust" would assume a truly alarming aspect, and it cannot be said this is an impossibility." (*The Agricultural Ledger No. 29 of 1896.*)

Prospects of an Alarming Expansion.

Remedial Measures.

872. In the present state of knowledge regarding this blight, the following remedial measures seem worthy of consideration :—

Removal of Shade Trees.

1st.—Where shade trees are found to cause the leaves of tea underneath to be coated with the grey lichenoid formations and the orange-red algal patches described above, the trees in question should be removed.

Fungicides.

2nd.—Where the leaves of any plot of tea are found to be abnormally attacked by the alga, they should be plucked off and destroyed, or washed with the fungicide already mentioned (*p. 418*). In neighbourhoods liable to the form that invades the stem, *every* orange-red-spotted leaf should be carefully removed and destroyed.

Removal of Affected Leaves.

Alga Removed from Seedlings.

3rd.—The seedlings in the nursery, if found to manifest the orange-red spots, should be washed with the above mentioned fungicide, and, in districts liable to the stem invasion, they should be dipped into a tub of that fluid at the time of transplantation, so as to ensure their freedom from any trace of the algal germs (*see method described, page 392*).

Careful Pruning

4th.—In gardens where the stem invasion occurs, careful pruning should be pursued with the object of cutting out the blight. The diseased bushes should also be marked before pruning, so that they may receive special attention. All the prunings should be instantly burned and the bushes copiously lime white-washed, in order to kill any trace of the germs of the disease that may be on the stem and branches

Prunings Burned.

Bushes Lime-washed.

Blights on the Stem.

5th.—In such gardens washing the shoots in Spring with the fungicide fluids, already mentioned, might be very beneficial. The washing perhaps had best be done with the hand, using a large mop. It seems probable that each year's attack originates from a hibernating spore that is probably held mechanically on the bark. A good washing would very possibly secure the destruction of such spores. By being repeated later, on the disease first showing signs of its presence, no doubt a check would be thereby given to a wider distribution. I would recommend comparative trials of one plot treated as directed in paragraph 4th above, the other with fungicide washings. **RED RUST. Washing with Fungicides in Spring.**

6th.—With limited plots of tea badly infected, I should fire the entire plot in February or in March. For this purpose do not prune in December. The alga would appear to be inactive in winter, if so, it can do little further harm. I should, therefore, leave the bushes, as they are, till the time selected for firing. This would allow the disease time to settle into its hibernating condition, the invaded twigs would also become thoroughly dry, and the firing would accordingly be more thorough and effectual. After the bushes showed signs of partial recovery, I should light prune, where found necessary. If firing be thought too drastic a treatment, collar prune and at once burn all the prunings. It is useless to try first one cure, and then another, where the blight has got a firm hold of the bushes. Better sacrifice the yield of the plot in question, for a year or 18 months, and exterminate the blight, rather than incur the risk of its extending. The manager of one of the Nowgong gardens writes me that, in spite of all efforts to cut out the blight, it is "increasing rapidly." If that be so, it is a mistake to experiment further with palliative treatment. Burning or collar pruning and washing the new shoots with fungicides, should they later on give indications of their being reinfested from neighbouring plots. By gradually adopting such treatment plot after plot, the blight would ultimately be got well in hand; severe measures are necessary for all badly affected plots. **Firing Badly Affected Plots. Collar Pruning. Severe Measures are Necessary for Badly Affected Plots.**

873. It would seem that, were some such plan systematically pursued, in districts liable to the dangerous form of the blight, much progress would be made towards eradication. In districts not so liable, every practicable effort should be made to prevent a concentration of the foliar phase of the blight, such as might be suspected to possibly favour the transformation into the second phase in the life of the **Foliar Phase Kept in Hand.**

CEPHALEUROS VIRESCENS.

species. The information we at present possess, justifies abundantly the statement that there can be nothing to gain, but possibly much to lose, by allowing the epidermal form of this alga to gain any further hold than it at present possesses on the tea bushes.

Diary Notes on "Red Rust."

Kaliden.

874. At Kaliden (visited 16th July), Red-rust was not very prevalent. It attacks the young shoots and kills downwards until it reaches the roots, but it takes two or three years to do so, the second, third and all subsequent shoots being killed each year. The leaves of the affected shoots turn whitish. It spreads rapidly by the prunings being buried. The first year a bush here and there, the second year more, and the third or fourth it may be all over the garden.

Takes Two or Three Years to Kill the Bush.

Pale Shoots Should be Cut off.

The pale shoots appear about May, and these should be cut off even though the rest is not then visible. The shoots should be cut down to secure being below the rust. It attacks the last year's shoots (the young wood not cut off).

Salonah.

At Salonah, visited 17th July, Red-rust was shown to me as the chief blight of the Nowgong District. Every garden has it, but Salonah perhaps the worst. It was first recognized in 1889 as a serious blight. Mr. Barry, of Kaliden, showed me the original correspondence which took place in 1889 between himself and Dr. King and Dr. Cunningham in which the fungus was determined as **Mycoidea parasitica.** It was then recommended that uprooting and burning was the only course. This has since, however, been found impossible, as whole gardens are more or less affected. Pruning off the affected parts undoubtedly checks the disease, but so far no effectual remedy has been discovered. A very significant feature is the fact that it does not seem to spread very far beyond its initial area.

Uprooting Recommended.

Seconee.

At Seconee (visited 18th July), Red-rust was found to be abundant and very destructive.

Tezpur.

At a garden in Tezpur District, visited ...... July, the manager seemed amused at the idea of Red-rust being of any moment although it was fairly abundant and sapping the life out of many bushes. I remarked, that it was the most severely red-rust-blighted plot of tea land I had yet seen. I pointed out to him that it was the cause of the bushes being often half their natural size. Of their being now full of dead shoots, I picked up many prunings that had been buried in the soil and found these covered with the rust. Hardly a bush near these rusted prunings had escaped the blight. There cannot be a doubt but that this disease is distributed and perpetuated by the pernicious habit of burying prunings I recommended that on no account should the prunings of a rust-affected plot be buried whatever views might otherwise be held for or against that practice. I should think I am well within the mark when I affirm that at least 10 per cent. of the portion of the garden to which I refer was giving not more than half its natural yield. In fact, over large portions of the estate few bushes could be found that were not affected to some extent. With energetic action now, cutting off all dead shoots, as also all those clearly affected, and by burning the prunings at once, by heavy pruning in Autumn and burning the prunings also, and by white-washing completely the stumps, the disease might be stamped out, and the plot made one of the best in the garden. Sooner than allow these diseases to get established, I should set fire to the entire affected plot. Were this done in February,

Prunings Buried Found to Contain the Blight.

Might be Eradicated.

Firing the Plot Preferable.

the disease would be entirely eradicated, and the bushes flush again in two months' time. (*Specimen No. 11978.*) ROOT FUNGI.

At another garden in Tezpur District, visited on the 20th July, I found Red-rust prevalent, but no mosquito—a fact that somewhat agrees with the condition that prevails on the opposite side of the Brahmaputra at Nowgong.

LXXII.—Fungi on the Roots of the Tea Plant.

ROOT FUNGI.

Conf. with paras. 39, 174.

111. (a & c) Rosellinia sp. (? R. radiciperda, *Massee*), and possibly two other forms.

ROOT FUNGI.

References.—*Bamber, Chem. and Agri. Tea, pp. 256-25; Indian Forester, Vol. XIII. (1887), pp. 290, 388; Massee, Kew Bulletin, 1896, pp. 1-5; Cunningham, Scientific Memoirs of Medical Officers of the Army of India—Part III. (1887), pp. 8-11; also Part X., pp. 22-24; Diseases of Plants, Karl Freiherr von Tubeuf, Translated by W. G. Smith, 200-204; Text-Book, Diseases of Trees by R. Hartig, Translated by Somerville and Marshall Ward, pp. 78-87.*

(*Reg. No. 140; Botanical Specimens Nos. 11891, 9164, and 509.*)

Repeatedly Mentioned in Indian Publications.

875. HISTORY.—The subject of tea bushes being killed by fungi on the roots, has been mentioned repeatedly in the Indian technical newspapers, in the *Journals, Agri.-Horticultural Society of India*, and in the *Indian Forester.* Until investigated by **Brigade-Surgeon-Lieutenant-Colonel D. D. Cunningham**, no progress was made. The first of **Dr. Cunningham's** papers, mentioned under the above paragraph of reference, gave the results of his examination of dried samples of roots that had been furnished to him. Unfortunately, since he had not the opportunity of examining fresh material, he could not procure cultivations of the fungus, and was thus neither able to determine its position nor to assign a name to it. His second paper (an advance proof of which has most obligingly been furnished me by the Director General, Medical Department), reviews the state of our knowledge of the subject.

Probability of There Being Two Species.

876. During my brief explorations in Assam, I was led to think that there might possibly be three root fungal parasites. The first one appears to originate saprophytically, and the second and third possibly parasitically. It is a well-known fact that certain shade trees within the garden, if killed or felled, cause the death of a number of tea bushes around their stumps. The trees with this evil reputation, most frequently mentioned, are the *Sum* (**Machilus**), *Bokain* (**Melia**), *Madar* (**Erythrina**), *Simul* (**Bombax**), indeed most soft-wooded trees. Many of the tea bushes killed in this manner, which I dug up and

Soft wooded Trees.

ROSELLINA SP.

Danger of Burying Prunings. *Conf. with para. 174.*

examined, had a fine white mycelial thread, running along the outside and also penetrating to the interior of the roots, and a similar formation was met with on the dead roots of the felled trees. It would in fact seem probable that the presence of any decomposing organic matter in the soil (prunings or otherwise) may, when least expected, give origin to the fungus here indicated.

The Possible Parasitic Species.

877. In the second parasite, the dead and dying bushes are found, perhaps remote from any shade trees and unconnected with any decomposing organic matter other than the tea bushes themselves. The leaves of diseased bushes are seen to gradually wither, to turn brown, and fall off without showing any fungal disease on their surfaces. This state of affairs very closely resembles the condition produced by grubs or wood-borers, only that in the insect-infested plants the leaves do not fall off the bushes, and death is, if anything, more gradual and local. If the stem near the ground of the fungal-infested bushes be examined, it will be found to be swollen, pulpy, and of a dark red colour. If the ground be uncovered, so as to reveal the roots, these will also be discovered to be irregularly swollen at interrupted positions. If the bark of the lower portion of the stem be examined, it will be found to crumble to pieces and to give indications of being diseased. There are no fungi to be seen externally, nor are the decomposed roots apparently penetrated by white mycelial cords, at least not such as are visible to the naked eye. It is clear, however, that a specific disease has been at work, and that it is readily communicative. Though starting originally with one bush, the infection gradually extends around, until a circular clump of bush may be dead or dying. This, so far as I am at present able to ascertain, was very possibly the disease examined by **Dr. D. D. Cunningham** mentioned above and from whose reports passages will be found below.

Stem Near the Ground Swollen.

Bark Crumbles to Pieces.

Circular Clump of Bushes Affected.

Peculiar Fungus met with in the Duars. *Conf. with paras. 882-3.*

878. I have recently received from the Duars what I regard as a third fungal root parasite. In this white mycelial felted patches and cords are readily seen within and around the roots and in the interspaces of the soil adjacent to them. Complete decomposition of the bark and of the sap wood may also be noted to have taken place, leaving the heartwood as cord-like bands. At this stage orange-coloured irregularly-shaped patches may also be witnessed on the bark of the roots which are doubtless connected with the general decomposition. The condition that prevails in many respects agrees

with the root fungus—**Rosellinia radiciperda**—which **Mr. Massee** has figured and described in the ***Kew Bulletin*** for 1896.

ROOT FUNGI.

The disease was stated to originate with one bush and to spread in a circular manner, the leaves withering and falling to the ground as the roots became attacked. The bushes were thus rapidly killed. But it was remarked that it had uniformly appeared in Jabika seedlings three or four years old and had passed over intervening plots of Manipur stock. Several independent centres were observed and none of these in any way associatated with the death of trees subsequent to the original clearance of the forest.

879. It would thus seem desirable in future inquiries that the possibility of two or more root fungi should be kept in view. As I had not sufficient time, while in Assam, to perform definite experiments, to ascertain the life histories of the root fungi, it will serve the purposes of the present report if I give here the results of **Dr. Cunningham**'s most recent investigations which, written by a mycologist of his experience, will be found a useful and suggestive contribution towards a knowledge of this very obscure subject, but I may repeat that I regard the passages that follow as very possibly having reference to the fungus briefly indicated in paragraph 877 :—

Dr. Cunningham's Report.

"Specimens of this disease were sent to me for examination by **Dr. King** during the winter of the year 1887. As I have already published a note regarding the subject in Part III. of this periodical,* it is unnecessary here to do more than to give a brief recapitulation of the characteristic phenomena. The morbid changes were purely confined to the lower extremity of the stems and the bases of the larger roots, and presented themselves externally in the form of numerous, conspicuous, irregularly-nodulated swellings, which occurred so closely over the base of the stem and origins of the larger roots as to be more or less completely confluent, whilst farther out along the course of the roots they occurred in isolated patches. Where they were present, the bark no longer retained its normal smooth texture and grey colour, but was roughened, friable, and deep brown, owing to the mixture of earth, derived from the surrounding soil, with the disintegrated tissues. In certain sites masses of material of rusty-brown colour and spongy texture were visible in fissures of the surface, and, on removing portions of the disintegrating

Bark Roughened Friable and Brown.

* Scientific Memoirs by Medical Officers of the Army of India.—*G. W.*

ROSELLINIA SP.

bark, these were seen to form portions of sheets and strands of similarly coloured material traversing the tissues in every direction. Such material was present throughout the entire thickness of the cortical tissues, and specially abundant at the level of the bast, where it was in many places spread out so as to form a continuous stratum over large areas. The wood appeared to be comparatively little affected, but was here and there interrupted by distinct wedge-shaped portions of a greyish tissue, with narrow, sinuous, blackish margins."

Rusty Brown Substance Found to be Masses of Mycelia.

"On microscopic examination, the rusty brown substance was found to be composed of dense, felted masses of mycelial filaments of brownish or greenish colour, and in those areas in which the invasion of the disease was progressing, but in which the tissues still retained their continuity, the cortex and bast were found to be everywhere permeated by fine filaments forcing their way between the constituent elements. In the earlier stages of disease, the wood appeared to be entirely unaffected, but, where it was far advanced, the mycelium tended to invade the medullary rays and to give rise to the discoloured radii previously alluded to."

"All attempts at cultivating the mycelium with the view of obtaining fructification failed entirely, which is hardly to be wondered at considering that it had evidently been primarily developed parasitically in connection with the living elements of the tissues, and that, by the time the specimens were submitted to examination, the latter were already dead and dried up. A certain amount of growth did occur in some cases, but it was soon arrested and was never attended by the production of any distinct reproductive bodies. The phenomena apparently indicated that the persistent masses of mycelium contained a certain amount of intrinsic nutritive material stored up within them which served to provide for a limited amount of growth, but that, when this had been expended, the latter ceased in the absence of any living host-tissues as a source of further supply. In those cases in which such limited growth occurred, the outer surfaces of the bark became covered by a coating of an orange colour, consisting of short, erect, emergent filaments originating from newly-developed horizontal extensions of mycelium within the substance of the tissues. The development of such emergent filaments in this case is probably an indication of the method in which the extension of the parasite from the roots of one plant to another is affected. The

Probable Method of Transmission.

Blights on the Roots.

growth which occurred in the present instance was, no doubt, very limited and only sufficient to give rise to a superficial coating of mycelium on the diseased tissues, but under normal conditions, where the mycelium is in full vigour and the host-tissues still capable of affording abundant nutritive supply, it may well be much more extensive and provide for the development of mycelial strands capable of traversing considerable areas of the soil and so of coming into contact with neighbouring healthy roots." **ROOT FUNGI.**

"As the specimens neither contained nor yielded anything save masses of purely mycelial elements, it is impossible to come to any definite conclusion in regard to the precise nature of the parasite, but taking the characters of the disease into account along with the well-ascertained fact of the destructive form of root-blight which prevails in European coniferous forests in connection with the invasion of the tissues by the mycelium of **Agaricus melleus,** *Vahl.*, it appears not improbable that it may be of HYMENOMYCETE origin."

Disease of Coniferous Forests.

Hymenomycete.

880. REMEDY.—"Fortunately, however, there can be no doubt in regard to the nature of the measures which ought to be adopted in order to limit the extension of the disease in any area within which it has established itself. All diseased plants ought to be at once removed and burned, and special care should be taken to remove the roots as thoroughly as possible, so that portions of them may not remain in the soil as sources of infection. If possible, moreover, it would be desirable not to replant the infected area for some time, and also to isolate it by means of digging a trench around it sufficiently deep to pass below the lowest level in the soil to which the roots normally penetrate. By such means any extension of mycelium connected with residual fragments of roots remaining in the soil to neighbouring uninfected areas would be effectually prevented, and in the absence of suitable nutritive supply the parasitic elements would, in the course of time, die out within the primarily infected one."

Bushes Should be Removed and Burned.

Conf. with para. 884.

Affected Areas Should not be Replanted for Some Time.

881. One or two dressings with lime, deep hoed into the soil, would no doubt hasten the decomposition of the fungus. As a rule, where root-fungi appear spontaneously, that is to say, in the absence of any evidence of communication from the roots of other trees, the soil will be found to be of a heavy black clayey mould that would be

Lime.

ROSELLINIA SP.

improved both by lime and deep sub-soil drainage. It would seem probable that such defects may act as predisposing conditions to an infestation of root fungi. The presence in a soil of an excessive amount of organic matter, more especially imperfectly decomposed animal or vegetable matter, must prove a source of constant danger, and consequently the oxidation of the soil by drainage becomes an imperative obligation.

Duars Root Fungus. *Conf. with para. 878.*

882. Since the above account of the probable three forms of root fungi found on the tea plant, had passed into final page proof, before Mr. George Massee's report on the form briefly indicated (*paragraph 878*) had reached India, I have thought it preferable to leave the account of these blights as originally prepared by me and to add the additional information, now brought to light, as supplementary. In my letter to Mr. W. T. Thiselton Dyer, Director, Royal Gardens, Kew, (11th November 1897), which forwarded samples of the diseased roots just then to hand from the Duars, I pointed out that it seemed to differ from the root fungi found by me in Assam (*paragraph 877*) in the peculiarities already briefly indicated. Mr. Massee's report sent in reply may be here given:—

Pyrenomycete.

"The fungus surrounding the root and base of the stem is some PYRENOMYCETE; sporangia are abundant, but unfortunately old and empty, consequently the name cannot be determined with certainty. It is very closely allied to **Rosellinia radiciperda**, *Massee*, and may prove to be identical with that species. The necessary measures for dealing with 'root fungi' are given in detail in the *Kew Bulletin*, 1896, pages 1-5."

883. The paper in the *Kew Bulletin*, to which Mr. Massee alludes, is one of great interest to planters, and I commend it to their careful consideration; but I may be permitted the remark that it is very significant a fungal blight on the roots of trees in New Zealand should occur (or some closely allied fungus) on the roots of the tea plant in India. The following passages from the scientific part of Mr. Massee's paper may be accepted as a sufficient introduction to his remarks on "Preventive Measures" which I make no apology for reproducing in full:—

Pourridie.

"Amongst the numerous root diseases of various plants caused by parasitic fungi, none are better known, or extending over a greater area than the *Pourridié* of the French, which occurs in

ROOT FUNGI.

France, Italy, Switzerland, Austria, South-West Germany, and has recently been recorded from three widely separated localities in Britain. The fungus causing this disease is called **Dematophora necatrix,** *Hartig*, which frequently devastates vineyards and orchards; its attacks, however, are unfortunately not confined to vines and fruit trees; potatoes, beans, beet, etc., are also destroyed, and Hartig states that the mycelium soon kills young maples, oaks, beeches, pines, and spruces."

"**Dematophora necatrix** is almost entirely confined to heavy clay *soils*, where the *water* drains away with difficulty, whereas **Dematophora glomerata,** *Viala*, an allied, but much rarer fungus, with a similar destructive habit, hitherto observed only in France, is met with attacking plants growing in loose sandy soil, where the sub-soil is wet."

"During the spring of the present year, a sample of soil was received by the Royal Horticultural Society from Mr. Hooper, Cambridge, Waikato, New Zealand, containing roots of apple trees attacked by a fungus, with a communication stating that the roots of fruit trees which penetrated the places where the fungus appeared to reside became infected, the fungus penetrating the tree and ultimately killing it. This material was forwarded to Kew for investigation. Sterile mycelium alone was present, which appeared to agree in every detail with that of **Dematophora necatrix,** and the fungus was provisionally referred to that species in a brief report published in the Journal of the Royal Horticultural Society (*xix., part I., 28*). The following account will give an idea of the injury caused by this fungus, as observed by Mr. R. Allen Wight, of Auckland, New Zealand *:—

Prevalence of Blights near Forest.

Conf. with paras. 824, 826.

"'This fungus, in the mycelial stage, attacks a great variety of tree roots, amongst the most conspicuous of which are the apple, pear, peach, and all other common orchard trees. The white thorn is also very subject to its attacks, as well as a great many Abies, and several of the native trees and plants. It also attacks the cabbage, the potato, docks, sorrel, fern, and in fact is almost omnivorous, which is a marked peculiarity. The only plants I have ever known to resist it are the resinous pines and roses; the former suffer at first, and the leaves turn yellow, but they ultimately recover, and I never knew one to succumb, whereas the contrary is the case with all other plants attacked.'"

"'The pest is most plentiful on the skirts of the primeval forests and on fern lands adjoining where no cultivation has ever been resorted to.

* *Journ. Mycol.*, Vol. V., p. 199.

ROSELLINIA SP.

Whole crops of potatoes are destroyed on such lands, and on dry lands where native tree stumps remain it is very prevalent. My own opinion is that it is a fungus native to, and probably peculiar to, New Zealand (in the North Island only). All my experiments with sulphur and lime have failed. Kerosine oil used in winter has alone been of any use, and that has been used pure in winter without killing the trees. The fungi of New Zealand are legion, and very destructive, but this is the worst, and particularly as it is confined to dry soils. Where I am now writing 500 trees have been killed within the last two years, and all remedies tried have failed. The apple scab, the short-hole fungus, the Oidium of the vine are terrible pests in New Zealand, and the settlers have more to fear from fungus growths than insect pests.'"

"As previously stated, the material received from New Zealand was, in the first instance, referred to **Dematophora necatrix.** Further development of the fungus, and the receipt of additional fruiting specimens from the same country, showed that this was a mistake, neither does the fungus belong to any known species. It will, therefore, be described as new, under the name **Rosellinia radiciperda.**"

"*Preventive Measures.*"

884. "Notwithstanding the fact that the New Zealand fungus proves to be distinct from the European root fungus, yet the general habit, mode of attack, and structure of the two are so similar, that the same methods of combating the disease will apply to both."

"Owing to the habit of the fungus in penetrating and spreading in the living tissues of the root of its victim, cure is practically outside the question when a plant is once permeated with mycelium; and keeping in view the varied modes of reproduction for facilitating the rapid spread of the disease, no efforts should be spared in the way of preventing such spreading, when the presence of the fungus is once detected."

"Undoubtedly the most frequent and rapid mode of spreading is by means of the mycelium travelling in the soil, and a good method of isolating diseased patches is to cut a narrow trench, from nine inches to a foot deep round such, care being taken to throw the excavated soil into the diseased portion, and not outside it. This method, which was first suggested by Hartig, for the purpose of preventing the spread of subterranean fungi in the German forests, cannot be too strongly commended, especially where the diseased patches are small in area. The amount of success depends entirely on the thoroughness, combined with an intelligent method of carry-

ing out the work. Half attempts invariably result in a loss of capital without benefit. It may be enough to suggest that the disease may be spread by the spores of the fungus, or infected soil being carried by the shoes of labourers, by dirty tools, wheels of carts, animals, etc., from diseased centres. Diseased and fallen trees, and especially stumps and roots, should be at once destroyed by burning. The soil surrounding diseased stumps should be burned after the stumps have been removed, so as to destroy the smaller diseased portions of the root that remained behind." **ROOT FUNGI.**

"A second preventive method, which has proved of service in France, is to lay bare the trunk as far below the surface of the soil as can be done without injury to the tree, and to densely coat the exposed trunk and adjoining soil with powdered sulphur. This should be repeated when the channel round the trunk becomes filled up with earth. If, as stated by Mr. Wight, the New Zealand fungus first attacks the trunk just below the surface of the soil, this method should prove beneficial if persevered with."

"Stagnant water should not be allowed to remain in the soil, as this favours the spread of the fungus."

"Finally, in those cases where the fungus has completely devastated large areas, it is probable that such will be deserted as unprofitable, the trees being allowed to lie and rot, and the fungus to spread in the soil. This is disastrous, being in fact a nursery for the development and diffusion of the enemy. It is not the object of this note to suggest whose business it is to prevent such short sightedness, but to impress emphatically that such a condition of things should not be tolerated."

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